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FRIDAY, NOVEMBER 23, 1917.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

ONE-HUNDRED-AND-SIXTY-FOURTH SESSION, 1917-1918.

SESSIONAL ARRANGEMENTS.

The Opening Meeting of the One Hundred and Sixty-Fourth Session was held on Wednesday, November 21st, when an address was delivered by ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, on "Science and its Functions." (See pp. 6-19, below.) The chair was taken at 4.30 p.m.

PAPERS TO BE READ BEFORE CHRISTMAS.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

NOVEMBER 28.—COLONEL MERVYN O'GORMAN, C.B., "Aerial Transport after the War."

DECEMBER 5.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "Discovery and Invention" (Inaugural "Trueman Wood" Lecture). ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

12.—LORD CHARNWOOD, "Technical Training for Disabled Soldiers and Sailors."

19.—PROFESSOR J. WEMYSS ANDERSON, M.Inst.C.E., M.I.Mech.E., Dean of the Faculty of Engineering and Lecturer in Refrigeration, University of Liverpool, "The Cold Storage Industry." THE HON. SIR THOMAS MACKENZIE, K.C.M.G., in the Chair.

COLONIAL SECTION.

Monday afternoon, at 4.30 p.m.:—

NOVEMBER 26. LIEUT.-COLONEL THE HON. SIR JOHN McCALL, M.D., LL.D., Agent-General for Tasmania, "Land Settlement within the Empire." THE RIGHT HON. WALTER H. LONG, LL.D., M.P., F.R.S., Secretary of State for the Colonies, in the Chair.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.:—

DECEMBER 13. D. T. CHADWICK, I.C.S., "The Trade of India with Russia, France, and Italy." THE RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, in the Chair.

PAPERS TO BE READ AFTER CHRISTMAS.

LORD LEVERHULME, "The Relations between Capital and Labour—Reasonable Hours, Co-partnership, and Efficiency."

SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Commercial Intelligence Department, "The Organisation of Commercial Intelligence." THE RIGHT HON. LORD FARINGDON in the Chair.

ALEXANDER NEWLANDS, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in the British Isles."

FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., in the Chair.

MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." SIR ASTON WEBB, K.C.V.O., C.B., R.A., in the Chair.

WILLIAM FRECHEVILLE, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of the Mineral Resources of the Empire." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., in the Chair.

ALFRED DICKINSON, M.Inst.C.E., "Water Power in India."

H. M. SURTEES TUCKWELL, M.I.Mech.E., "The Tata Iron and Steel Works" (India).

SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India."

SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912-17, "British Guiana."

C. DU P. CHIAPPINI, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

The following series of papers has also been arranged, dealing with the Application of Scientific Research to the development of particular British Industries:—

REGINALD S. CLAY, D.Sc., Principal of the Northern Polytechnic Institute, "The British Pianoforte Industry."

GEORGE MARTINEAU, C.B., "The Sugar Industry."

JOHN B. FARMER, D.Sc., M.A., F.R.S., F.L.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber-Planting Industry."

W. LAWRENCE BALL, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

SIR WILLIAM GEORGE WATSON, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." SIR ARTHUR D. STEEL-MAITLAND, Bt., M.P., in the Chair.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

January 17, February 14, March 14, April 18, May 30.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

February 5, March 5, April 30.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced) :—

H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, "Progress in the Metallurgy of Copper." Three Lectures.

December 3, 10, 17.

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." Three Lectures.

January 21, 28, February 4, at 8 p.m.

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Economic Condition of the United Kingdom before the War: the Real Cost of the War: and Economic Reconstruction." Three Lectures.

February 18, 25, March 4.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22, at 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13 and 14, at 4.30 p.m.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m. :—

P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, "Animal Camouflage." Two Lectures.

January 2, 9.

PROCEEDINGS OF THE SOCIETY.

THE SOCIETY was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom: and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country." In 1908 the Society was granted the privilege of adding "Royal" to its title.

Fellowship.—At the Annual General Meeting held on June 24th, 1914, a By-Law was made authorising all Members of the Society to use the designation of Fellow.

Ordinary Meetings.—Meetings are held every Wednesday during the Session, at which papers on subjects relating to inventions, improvements, discoveries, and other matters connected with Arts, Manufactures, and Commerce are read and discussed.

Indian Section.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

Colonial Section.—This Section was formed in 1874 under the title of the African Section. It was enlarged in 1879, to include the consideration of subjects connected with the Colonies and Dependencies. Four or more Meetings are held during the Session.

Cantor Lectures.—These Lectures originated in 1863, with a bequest by Dr. Cantor. The Lectures deal with the latest applications of Science and Art to practical purposes, and are, as far as possible, experimentally illustrated.

Fothergill Lectures.—Courses of Lectures, similar to the Cantor Lectures, are given from time to time under this bequest.

Howard Lectures.—The bequest of Mr. Thomas Howard (1872) is now devoted to occasional courses of Lectures on motive power and its applications.

Shaw Lectures.—Under the Shaw bequest Lectures on Industrial Hygiene are given from time to time.

Aldred Lecture.—The bequest of the late Dr. Aldred has been devoted to the establishment of an Annual Lecture.

Cobb Lectures.—Funds have been provided for occasional Lectures in memory of the late Mr. Francis Cobb.

Juvenile Lectures.—A Short Course of Lectures, suited for a Juvenile audience, is delivered to the children of Fellows during the Christmas holidays.

Admission to Meetings. — Fellows have the right of attending the above Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Fellow can admit two friends to the Ordinary and Sectional Meetings, and to the Cantor and other Lectures. Books of tickets for the purpose are supplied, but admission can also be obtained on the personal introduction of a Fellow. For the Juvenile Lectures special tickets are issued

Journal of the Royal Society of Arts.—The *Journal*, which is sent free to Fellows, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

Examinations.—Examinations, founded in 1854, are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person. The subjects include the principal elements of Commercial Education and Music. Full particulars of the Examinations can be had on application to the Secretary.

Library and Reading-room.—The Library and Reading-room are open to Fellows, who are also entitled to borrow books.

A History of the Society, written by Sir Henry Trueman Wood, Secretary of the Society from 1879 to 1917, has lately been published (John Murray, pp. 558, 15*s*. net), and can be obtained from any bookseller. It gives a history of the Society's work from 1754 to 1880.

Conversazioni are held, to which Fellows are invited, each Fellow receiving a card for himself and a lady.

Election of Fellows.—Candidates are proposed by Three Fellows, one of whom, at least, must sign on personal knowledge; or are nominated by the Council.

The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day preceding election; or a Life Subscription of Twenty Guineas may be paid. There is no Entrance Fee.

CALENDAR FOR THE SESSION.

The following is the Calendar for the Session 1917–1918. It is issued subject to any necessary alterations :—

NOVEMBER, 1917			*DECEMBER, 1917*			*JANUARY, 1918*			*FEBRUARY, 1918*		
1	Th		1	S		1	Tu		1	F	
2	F		2	S		2	W	Juvenile Lecture I.	2	S	
3	S		3	M	Cantor Lecture I. 1	3	Th		3	S	
4	S		4	Tu		4	F		4	M	Cantor Lecture II. 3
5	M		5	W	Ordinary Meeting	5	S		5	Tu	Colonial Section
6	Tu		6	Th		6	S		6	W	Ordinary Meeting
7	W		7	F		7	M		7	Th	
8	Th		8	S		8	Tu		8	F	
9	F		9	S		9	W	Juvenile Lecture II.	9	S	
10	S		10	M	Cantor Lecture I. 2	10	Th		10	S	
11	S		11	Tu		11	F		11	M	
12	M		12	W	Ordinary Meeting	12	S		12	Tu	
13	Tu		13	Th	Indian Section	13	S		13	W	Ordinary Meeting
14	W		14	F		14	M		14	Th	Indian Section
15	Th		15	S		15	Tu		15	F	
16	F		16	S		16	W	Ordinary Meeting	16	S	
17	S		17	M	Cantor Lecture I. 3	17	Th	Indian Section	17	S	
18	S		18	Tu		18	F		18	M	Cantor Lecture III. 1
19	M		19	W	Ordinary Meeting	19	S		19	Tu	
20	Tu		20	Th		20	S		20	W	Ordinary Meeting
21	W	Opening Meeting	21	F		21	M	Cantor Lecture II. 1	21	Th	
22	Th		22	S		22	Tu		22	F	
23	F		23	S		23	W	Ordinary Meeting	23	S	
24	S		24	M		24	Th		24	S	
25	S		25	Tu	CHRISTMAS DAY	25	F		25	M	Cantor Lecture III. 2
26	M	Colonial Section	26	W	*Bank Holiday*	26	S		26	Tu	
27	Tu		27	Th		27	S		27	W	Ordinary Meeting
28	W	Ordinary Meeting	28	F		28	M	Cantor Lecture II. 2	28	Th	
29	Th		29	S		29	Tu				
30	F		30	S		30	W	Ordinary Meeting			
			31	M		31	Th				

MARCH, 1918			*APRIL, 1918*			*MAY, 1918*			*JUNE, 1918*		
1	F		1	M	*Bank Holiday*	1	W	Ordinary Meeting	1	S	
2	S		2	Tu		2	Th		2	S	
3	S		3	W		3	F		3	M	
4	M	Cantor Lecture III. 3	4	Th		4	S		4	Tu	
5	Tu	Colonial Section	5	F		5	S		5	W	
6	W	Ordinary Meeting	6	S		6	M		6	Th	
7	Th		7	S		7	Tu		7	F	
8	F		8	M	Cantor Lecture IV. 1	8	W	Ordinary Meeting	8	S	
9	S		9	Tu		9	Th		9	S	
10	S		10	W	Ordinary Meeting	10	F		10	M	
11	M		11	Th		11	S		11	Tu	
12	Tu		12	F		12	S		12	W	
13	W	Ordinary Meeting	13	S		13	M	Cobb Lecture 1	13	Th	
14	Th	Indian Section	14	S		14	Tu	Cobb Lecture 2	14	F	
15	F		15	M	Cantor Lecture IV. 2	15	W	Ordinary Meeting	15	S	
16	S		16	Tu		16	Th		16	S	
17	S		17	W	Ordinary Meeting	17	F		17	M	
18	M		18	Th	Indian Section	18	S		18	Tu	
19	Tu		19	F		19	S	WHIT SUNDAY	19	W	
20	W	Ordinary Meeting	20	S		20	M	*Bank Holiday*	20	Th	
21	Th		21	S		21	Tu		21	F	
22	F		22	M	Cantor Lecture IV. 3	22	W		22	S	
23	S		23	Tu		23	Th		23	S	
24	S		24	W	Ordinary Meeting	24	F		24	M	
25	M		25	Th		25	S		25	Tu	
26	Tu		26	F		26	S		26	W	Annual General Meeting
27	W		27	S		27	M		27	Th	
28	Th		28	S		28	Tu		28	F	
29	F	GOOD FRIDAY	29	M		29	W	Ordinary Meeting	29	S	
30	S		30	Tu	Colonial Section	30	Th	Indian Section	30	S	
31	S	EASTER SUNDAY				31	F				

The Cantor Lectures, the Ordinary Meetings, and the Meetings of the Indian Section and the Colonial Section will be held (unless otherwise announced) at Half-past Four o'clock.

The Annual General Meeting will be held at Four o'clock.

The Juvenile Lectures will be given at Three o'clock.

PROCEEDINGS OF THE SOCIETY.

FIRST ORDINARY MEETING.

Wednesday, November 21st, 1917; ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Aplin, William, Assoc.Inst.M.M., Technical College, Mount Morgan, Queensland, Australia.

Armstrong, Ernest, Linton House, Haydon Bridge, Northumberland.

Banatvala, Curtsetji Jamsetji, B.A., Mount villas, Bandra, Bombay, India.

Bayley, Victor, C.I.E., Assoc.M.Inst.C.E., care of Railway Board, Simla, India.

Bhándare, Rao Bahadur S.T., Inspector-General of State Records, Lashkar, Gwalior, Central India.

Blair, Lieut. John Hamilton, R.N., D.S.O., H.M.S. "Titania," Submarine Depôt, care of G.P.O., London.

Clowes, William Archibald, Berwyn, St. Mary's road, Ditton Hill, Surrey.

Collier, Harry Samuel, The Orchard, Buckland, near Betchworth, Surrey.

Cox, W. Howard, Union Central Life Insurance Co., 1107, Union Central Building, Cincinnati, Ohio, U.S.A.

D'Abreu, Aubyn Reginald, 3rd Divisional Signal Company, Royal Engineers, Mesopotamia Expeditionary Force.

Dhruva, Maganlal Dhaneshwar, Nandod, Rajpipla State, Rewakantha, India.

Gwyther, Harry Earlston, M.Inst.C.E., The Leopoldina Railway Company, Caixa 291, Rio de Janeiro, Brazil.

Hamshaw, William Hamlin, J.P., 61, York mansions, Battersea Park, S.W. 11.

Hancock, Walter Charles, 10, Upper Chadwell street, Myddelton square, E.C. 1.

Hay, Leslie, Messrs. Finlay & Co., Ltd., Calcutta, India.

Henriques, Elias Cosmas, A.R.I.B.A., Culvem, District Thana, Bombay, India.

Hutchinson, C. M., B.A., Imperial Department of Agriculture, Pusa, India.

Jack, Robert Ernest, I.C.S., United Service Club, Calcutta, India.

Jennings, Frederick W., Messrs. Ashwell & Nesbit, Ltd., 12, Great James street, Bedford row, W.C. 1.

Johnson, Arthur Laurence, M.A., Southcote, Cambridge road, Middlesbrough.

Johnson, Harold, Macmillan building, 276, Hornby road, Bombay, India.

Jones, F. J. Clinch, 20, Longley lane, Northenden, Cheshire.

Jordan, Frank, 34, Trafalgar place, Brynmill, Swansea.

Kemp, Walter Lowther, Messrs. Barker & Co., Singapore, Straits Settlements.

Krishnagar, Maharaja of (Kshaunish Chandra Roy Bahadur), The Palace, Krishnagar, District Nadia, Bengal, India.

Kroll, Clifton H., 311, California street, San Francisco, California, U.S.A.

Laird, James, 13, Berlin road, Catford, S.E. 6.

Lang, Rev. George, Anniston, Alabama, U.S.A.

Locker, Thomas Cecil, A.M.I.Mech.E., 12, Salisbury street, Warrington.

Macdonald, James, Government Marine Surveyor's Office, G.P.O. building, Hong-Kong, China.

Makower, Ernest S., 8, Cambridge terrace, Regent's Park, N.W. 1.

Matthews, Dr. Joseph Merritt, 5, Berwyn street, East Orange, New Jersey, U.S.A.

Mawson, George Thomas, The Dunes, Marve, Salsette, Bombay, India.

Mews, Walter, Loxdale, Portslade, Sussex.

Molson, John Cavendish, M.D., L.R.C.P., F.C.S., The Gables, Hayward's Heath, Sussex.

Moore, William Withers, 32, Cleveland square, Hyde Park, W. 2.

Muto, Sanji, Kanegafuchi Spinning Company, Ltd., Hiogo, Japan.

Naidu, Mallem Chengalvarayulu, 1A, 36th street, Rangoon, Burma.

Nashipur, Maharaja of (Ranajit Sinha), Nashipur Rajbati, Nashipur, District Murshidabad, Bengal, India.

Nicholson, Harry, B.Sc., 30, Emanuel avenue, Acton, W. 3.

O'Leary, Very Rev. Peter J., Summerhill College, Sligo, Ireland.

Poulsson, Ths. H., Bredgt 5, Stavanger, Norway.

Richardson, Robert Taylor, J.P., The Starlings, Barnard Castle, Co. Durham.

Rowell, Herbert, M.Inst.C.E., M.I.N.A., The Manor House, Jesmond, Newcastle-on-Tyne.

Ruthen, Charles Tamlin, L.R.I.B.A. M.S.A., Bank chambers, Heathfield street, Swansea; and 33, Furnival street, Holborn, E.C. 1, and H.M. Office of Works, Storey's gate, S.W. 1.

Santosh, Raja of (Manmatha Nath Ray Chowdhury), Santosh, Tangail, District Mymensingh, Bengal, India.

Scott, James Lang, Twynholm, Bramley, Surrey.

Shewan, Hon. Robert Gordon, Messrs. Shewan, Tomes & Co., Hong-Kong, China.

Sneath, William H., Electric Furnace Products Co., Sande, Ryfylke, Norway.

Solman, Harry, 13, Ironmonger lane, E.C. 2.

Starr, Louis, M.D., LL.D., 123, Pall Mall, S.W. 1.; and Philadelphia, U.S.A.

Tait, William Archer, D.Sc., M.Inst.C.E., 9, Victoria street, S.W. 1.

Tarlton, Edward Smedley, Kumardubi Engineering Works, Barakar P.O., India.

Tobutt, John James, 67, Holland road, Willesden, N.W. 10.

Waite, Captain C. S., C.I.E., care of Railway Board, Delhi, India.

Wee Guan Toh, Sandakan, British North Borneo.

White, James, Commission of Conservation, Ottawa, Canada.

Wilcock, Arthur, 25, Hanover house, Regent's Park, N.W. 8.

Wilson, Anthony, J.P., Middle Ruddings, Braithwaite, near Keswick, Cumberland.

Wilson, Leonard, 926, Pennsylvania avenue, N.W., Washington, D.C., U.S.A.

Wood, Sir Henry Trueman, M.A., 3, Prince Edward's Mansions, W. 2.

Wright, A. J., L.D.S., D.M.D., 76, William street, Perth, Western Australia.

The CHAIRMAN delivered the following

ADDRESS.

This is the opening Meeting of the 164th Annual Session of this Society, and at the outset I desire to express my appreciation of the honour that my colleagues on the Council have conferred upon me in electing me to this Chair. The position of Chairman of the Council of the Royal Society of Arts is one of great responsibility, and it is no light task to address a Society before whom even the redoubtable Dr. Johnson failed when he essayed to speak, his flowers of oratory forsaking him, as he himself expressed it. I fear, moreover, that I shall not find it easy to reach the high standard set me by my eminent predecessors; but, relying on your kind forbearance, I will endeavour to do my best.

It is with much regret that I have to draw attention to the great loss that the Society has sustained through the resignation of Sir Henry Trueman Wood of his office as Secretary, which office he has held for a period of no less than thirty-eight years. This period exceeds by as much as eight years the service of any one of the twelve gentlemen who have held that important position since the Society was founded in 1754. Indeed, for so long and so intimately has Sir Henry been associated with all its activities that for us moderns it seems almost impossible to think of the Society without him.

You will, however, I am sure, all be pleased to learn that, though Sir Henry Wood has retired from the Secretaryship, he has been nominated as a Fellow of the Society, and will, we hope, shortly rejoin the Council in a new capacity. Consequently we expect still to enjoy his kindly presence at our meetings, and to have the great advantage of his ripe experience in our deliberations.

I have also great pleasure in being able to announce that in commemoration of Sir Henry Wood's long, arduous, and faithful service to the Society, it has been decided to found a Sir Henry Trueman Wood Lecture, to be given annually in this room by some eminent person, and that the inaugural lecture of this series will be given on December 5th by my distinguished predecessor in the Chair, Sir Dugald Clerk. I am sure that you will all agree that no one better could be found to give the first of these lectures, and I am sure also that you will not wish to let this, our first opportunity, pass without congratulating Sir Dugald himself on the honour which has recently been bestowed upon him by the King for his services to the nation.

Finally, before entering upon the subject-proper of my address, I desire to bring to your notice that we have appointed as our new Secretary, Mr. G. K. Menzies, who is responsible for having prepared the excellent programme for the new session that has been circulated amongst you. Mr. Menzies will undoubtedly have a difficult task in succeeding so experienced and so universally revered a predecessor as Sir Henry Wood, but he has had the advantage of serving under Sir Henry as Assistant Secretary for the past nine years, and has therefore a unique knowledge of what is wanted in a position which has been held by a number of very zealous officials, and for which, as you will perhaps remember, no less a personage than Oliver Goldsmith was once an unsuccessful candidate.

SCIENCE AND ITS FUNCTIONS.

In considering what subject I should choose for my address on this occasion I have been mindful of the objects of the Society which, as you know, exists for the encouragement of Arts, Manufactures, and Commerce.

In this connection the word "Arts" must not, of course, be restricted to its æsthetic sense, but should be interpreted in its widest possible meaning, so as to include the mechanical, industrial, and useful arts generally, and all those varied descriptions of activity that are the business of the artificer of every trade and of every denomination. Now, as I propose to show you, what is at the base of all the arts, as also of all manufactures, and as commerce consists of dealings in these manufactures, at the base of all commerce as well, is "Science." Without

science neither arts, manufactures, nor commerce could ever have existed at all, and without science none of these, as existing, could make any progress. It is, therefore, I hope, not inappropriate if I address myself this afternoon to some discussion of science and its functions. Now, what is science, and what are its functions? Huxley has defined "science" as "trained and organised common-sense." From an etymological point of view the word is synonymous with learning and knowledge, but in general usage a more restricted and definite meaning has been adopted, and in ordinary parlance by "science" we mean "natural science," or the systematised knowledge of natural phenomena and the relations that exist between them. Now, although this does not seem to be fully apprehended by the multitude, it is to science, understood in this sense, that is due the whole material progress of mankind from the earliest times. Primitive man may not himself have been conscious of the fact, but even in his earliest endeavours to meet the exigencies of his condition, it was science that he called to his aid. It was his faculty to observe natural phenomena and to adapt these phenomena to his needs, that first differentiated him from the beasts of the field.

From this faculty arose his use of weapons, fashioned by himself, for the chase and for defence against his enemies. Hence begot he the use of the sling and missile, and of the bow and arrow. Hence sprang his use of fire to cook his food, to light his way after dark, to bake and harden his bricks and tiles, his earthenware pots and utensils, to reduce his metals from the ore, and to fashion his bronze and his iron swords and spears. By what was, in fact, scientific observation he learnt to adapt the millstone to grind his corn, and the grindstone to sharpen his tools. Much systematised knowledge must have been acquired and put to use by primitive man, in the practice of prehistoric agriculture and in the production of instruments such as the spade, the hoe, the axe, the plough, and the reaping-hook, which he designed for tilling the ground and garnering the harvest. At some period the wheel must have been first applied to the primitive cart, and the canoe and coracle must have been fashioned for transit over rivers, and for navigation on lake and sea. Then there is the domestication of animals, their breeding, and the training of some of the species to carry burdens and to afford tractive and other assistance to their masters.

At an early age in these northern climates man must have discovered some method of tanning to preserve the skins in which he had perforce to clothe his body, while later he invented the weaving of rude cloth, sewing, and other similar devices. All this we learn from the remains left behind him by primitive man in the caves in which he lived and died, and in the sepulchres in which he was in the end laid to rest. And so man progressed in developing his powers and in applying to his requirements the things that he found around him, until he reached the comparatively high state of civilisation of which we learn from the Bible narrative and other ancient scripts, from the engraved stones of the Chaldeans, the moulded tiles with their cuneiform lettering of the Assyrians, from the Papyri and hieroglyphics of the Egyptians, and the great architectural remains of Babylon, Nineveh, Cnossus, and Egypt. In all of these we see the results of the observation of natural forces and phenomena, and their adaptation to human needs; in all of them we discern the first fruits of applied knowledge, in all of them we have illustrations of the functions of elementary science.

So far we have only discussed the considerations that moved early man to apply scientific methods to the improvement of his material condition, but at a very early date other things were also attracting his attention. The nature, phases, and movements of the sun and moon, and the other heavenly bodies, were objects for his notice and speculation, as also the structure, position, and relation to the rest of the universe of his own earth. These occupied his thoughts and excited his wonder, quite apart from utilitarian considerations, and were the beginnings of pure as distinct from applied science.

Since the earliest times, man, like his poor relation the monkey, has always been of a curious disposition, and has wanted to know the why and wherefore, as well as the mechanism of all the phenomena that he sees about him. No doubt much early science, especially in the fields of astronomy and alchemy, was practised as a cult, with a view to impressing and mystifying the common people, but at the back of it all there can be little question that the great force that impelled inquiry into nature, both in ancient times and in the modern world, was curiosity, which in itself is probably of all human emotions the one that has been most conducive both to intellectual and to material progress.

And now, with the appearance in history

of that wonderful people the Greeks, we come for the first time in personal contact with the scientific thoughts and the scientific theories of individual philosophers. Prior to that period there must have been scientific thinkers, but we have no distinct record of what were their scientific ideas. All that remains are portions of some of their material constructions, and some accounts of others that time and decay have destroyed. Thales of Miletus, one of the seven wise men of the Grecian golden age, though he lived some 600 years before our era, is no mere name. He was the founder of the physical school of Greek philosophy, who first began to consider the nature of things, and was the first to observe electrical action. To Democritus, a Greek of the fourth century B.C., we owe the earliest ideas about matter; while to Hippocrates, another early Greek, are due the beginnings of medicine and biology. To him is ascribed the immortal and pregnant phrase that while "Life is short, Art is long, Opportunity fleeting, Experiment uncertain, Judgment difficult"—an aphorism in which is summed up for all time the difficulties with which the scientific investigator has to contend. And so we pass on to that most famous of classical philosophers, Aristotle, whose writings have done more than that of any other man to influence the progress of science, and whose authority was so great that it bound the scientific world in iron fetters for centuries. In the great library and museum which was founded in the third century B.C., by Ptolemy at Alexandria, then the intellectual and commercial capital of the Grecian world, we find the apotheosis of Greek scientific activity. Here were preserved all the scientific writings and records that a world-wide search had enabled the founder to collect. Here were taught the philosophy of Aristotle and the geometry of Euclid. Here Claudius Ptolemy experimented in optics, and wrote his great work on the construction of the heavens. Here Eratosthenes measured the earth. Here Ctesibius invented the fire-engine, and Hero the first steam-engine, which it is interesting to note was a simple form of steam turbine. Here worked Archimedes, the most famous mathematician and physicist of the ancient world, who laid the foundation of hydrostatics, elucidated the theory of the lever, and invented the burning-glass and the screw-pump which still bears his name. As a man of science the world produced no equal to him for nearly two thousand years. But the days of the great library were numbered, and within those marble halls the drip of the water clocks of Apollonius were counting drop by drop, and second by second, the approach of the catastrophe. During the siege of Alexandria by Julius Cæsar, the library and all its contents were burnt—a fitting funeral pyre to the glory that was Greece.

The Romans made no contributions to pure science at all to be compared with those of the Greeks. They were a practical rather than a speculative people, and were great builders, engineers, and road-makers. Size, solidity, and quantity rather than novelty were the outstanding features of their scientific work. They were not like the Greeks, ever seeking after some new thing.

When Rome fell into decay, and the gloom of the dark ages settled down upon Europe, there was for a time an almost complete halt in the progress of science. True, some vestige of learning still struggled to maintain itself in what was left of the Alexandrian library, but this was finally extinguished by the latter's second destruction by order of the Arabian Khalif, Omar. After this, it is somewhat surprising that the next revival in scientific investigation took place amongst the Arabians themselves, now become a highly cultured people. To this revival we owe the invention of algebra, the beginning of systematic chemistry, and much new work in astronomy, medicine, mechanics, and metallurgy. One of the most famous of the Arabian experimental philosophers was Alhazan, who lived shortly before the Norman Conquest of England.

Of all scientific inventions perhaps the one, and a very simple one, too, that has most influenced the history of the world is that of printing. When all literature had to be laboriously copied by hand, it is obvious that books must have been scarce and expensive, and could not be widely circulated. Printing changed all that, and rendered for ever impossible the recurrence of such a disaster to civilisation as the burning of the Alexandrian Library, where, owing to there being no duplicates, much of the world's knowledge was totally lost. Printing has, no doubt, recorded much more trash than wisdom, but it is difficult to appreciate what the world would be like to-day without our libraries, our books, and our newspapers. Life would certainly be very different from what it is. More important than that, however, is the enormous impetus that printing gave and still gives to the diffusion of knowledge, and the effect of this on scientific and industrial progress. When, there-

fore, there began in Europe that great revival of learning known as the Renaissance, it was the printing press that became its principal coadjutor, and caused things to move at a rate much faster and on a scale much larger than ever before. It was with fundamental concepts that the new learning had first of all to contend, particularly with the geocentric theory of the universe, which gave to the earth and to human affairs quite an undue importance, and also with the authority of Aristotle which had become an article of faith and defied all new ideas. Both of these lost causes were defended with the full force of the Roman Church, with a consequent loss of prestige to the latter, which had not a little to do with the success of the Reformation. Polemical questions such as these, however, have but slight connection with the objects of our Society, so it is unnecessary to dwell upon them here. By the end of the sixteenth century experimental science, as opposed to the barren speculations of the school men, was again being practised in Europe with noteworthy results, while, a little later, Francis Bacon published his famous "Novum Organon," and thus became the apostle of the revival of this experimental method of attacking scientific problems. On this method, which had been practically abandoned for some hundreds of years, all modern science is based, and as soon as its practice recommenced results of the highest importance began rapidly to accumulate. How a dread of the tentacles of "authority" still lingered in scientific circles is, however, to be seen in the fact that when the Royal Society was founded in 1663, the Fellows took for their motto the words, "Nullius in Verba," an excerpt from a line in Horace which reads, "Not pledged to swear by the words of any master." To-day it is difficult to realise what a hold authority had come to have on even scientific ideas, and how even as late as the seventeenth century, antiquated and frequently unsound scientific principles, as enunciated in the writings of Aristotle, were still regarded as something that had to be faced when dealing with new problems.

And now we have arrived at a period when there commenced those organised efforts in scientific investigation, and those widespread and continuous endeavours to apply the results thus obtained to practical ends, that have produced during the last two centuries such marked effects on civilisation. We have now, in fact, a better opportunity than ever before of seeing what are the functions of science.

To arrive at some measure of the vast changes that have been brought about, let us consider how matters stood one hundred and fifty years ago, say in 1754, the year in which our Society of Arts was founded. At that date the steam-engine had not yet assumed a practical form, and apart from some small use of water and wind power, when mechanical work had to be done this was accomplished by the aid of the muscular effort of men and animals. The question of power supply was, in fact, in the same condition that had existed for thousands of years, and, in consequence, the employment of machinery of all descriptions that required power to drive it was extremely limited. Nor as regards travel for persons, or transit for goods, were things very different. The steamship was unthought of, and ocean journeying was no faster, and but little more certain, than in the days of Columbus. Railways in the modern sense were non-existent, and even the coaching era had scarcely begun. Travelling of all sorts was no more rapid or more convenient than in the days of the Romans. Indeed, emperors such as Hadrian and Severus, who visited this country in late classical times, probably made the journey to and from Rome quite as expeditiously, and very likely even much more comfortably, than did any traveller of the eighteenth century. Furthermore, at the time of which I speak, the communication of intelligence was limited to the speed at which postmen could travel, for, of course, there were no electric telegraphs, such as have shortened the time of communication with the ends of the earth to a few seconds, and have reduced even ambassadors to the status of clerks at the hourly beck and call of the Home Government. In the eighteenth century, moreover, illuminating gas and electric light had still to be invented, public lighting was practically non-existent, and even in London, and other large cities, linkmen with torches were required to light the passenger to his home after dark. If printing was in use it was slow and expensive, without any of the modern mechanical, photographic, and other adjuncts that have rendered possible our numerous newspapers and the other derivatives of the press. Nor were there any proper systems either for water-supply or for the disposal of sewage. Disease, born of filth and neglect, stalked through the land practically unchecked. Medicine was still almost entirely empiric. Little or nothing was known of the causes and nature of illness, of infection by bacilli, or of treatment by inoculation. Anæsthetics had not yet been applied,

and the marvels of modern surgery were undreamt of. It would be easy to multiply instances, but in the aggregate it is not inaccurate to state that at the time this Society was founded the general mode of life had not much improved on what obtained in civilised Europe in the days of the Antonines, while, in some respects, it fell much short of this.

To-day we live altogether in a different world, in an age of travel accelerated by steam, petrol and electricity; of railways on the level, overhead and in tubes; of trams and motor omnibuses, of bicycles and motor-cars; of steel ships and steel bridges; of mills and factories, with their products of every possible description; of telegraphs by wire and wireless; of telephones; hourly newspaper editions and tape machines; of electric light indoors and outside; electric power for every purpose, from carrying us upstairs to brushing our hair and our boots; of gas fires and gas cookers; of electric bells and electro plate; of automatic machines and thermos flasks; of pianos, pianolas, concertinas and gramophones; of kodaks, snapshots, and cinematographs; of fountain-pens, sewing-machines, typewriters, lawn-mowers, knife-grinders, vacuum cleaners, and barographs; of cigarettes and lucifer matches, which are much newer than many people think; of innumerable new and cheap textile fabrics, of plate glass, aluminium, indiarubber, celluloid, vulcanite, and all manner of new artificial materials; of laughing gas for having a tooth out, of chloroform and ether for more serious operations; of X-rays for inspecting our interiors; of dozens of new medicines for every ailment, and ailments with new names discovered every day; of balloons and aeroplanes, in which we may all soon be travelling; besides all the masses of diverse machinery used in manufacture, in agriculture, and in the arts. All these things, as well as many more, are younger than our Royal Society of Arts.

It has been the fashion to divide what we understand by science into two portions, pure science and applied science; but these are only halves of one great whole. Pure science, which is the domain of the research worker and the discoverer, supplies the data, physical, chemical, and mechanical, which it is the function of applied science to turn to account for practical utilitarian purposes. For this latter operation are required the services of the inventor and the engineer, and other experts of a similar character.

Even great scientific discoveries have in some cases been made by chance, but generally only by men of marked intuition and acutely developed powers of observation. More often they have been the result of prolonged thought, and laborious and patient investigation, with delicate experiments. Many have been the issue of elaborate mathematical reasoning. As subjects become more complex, complete knowledge of what has been done before in the same field is more and more necessary. One of the most fruitful sources of new discovery in all branches of science in modern times has been the greater attention paid to quantitative as against merely qualitative research, very accurate measurements of every kind being one of the special features of present-day research methods. A noteworthy point is that the results of research are cumulative, one discovery almost invariably leading to others in course of time.

One of the most exasperating questions that can be put to a scientific man who has just discovered some new thing, and at the same time a question that nearly always is put to him, is "What is the use of it?" Faraday's reply, when such an inquiry was made of him in regard to his discovery of electro-magnetic induction, is a good one. Like many a wise man before him, he replied to the question by asking another. This was: "What is the use of a baby?" As a matter of experience all discoveries in pure science, however recondite and however seemingly useless at the moment, find their practical application sooner or later. It may not be for years or even for centuries, but in its own time the application comes. Invention is a faculty of the imagination; the inventive temperament being akin to the artistic temperatment, and real inventors, like true artists, are born and not made. In order to be great, both must have creative powers in a high degree. Unless gifted at birth with the inventive afflatus, the ordinary man can no more by taking thought make himself an inventor than he can add a cubit to his stature. At the same time the inventor, to be fully successful, must be suitably educated. By study and the acquisition of knowledge he widens his scope, and can apply his gifts in fields of invention to which, without such knowledge, he could not hope to aspire. At the same time, it is a noticeable and curious fact that many great inventions have been made by men whose ordinary vocations were quite outside the particular field in which their inventions applied. This is no doubt a case of the fresh mind of the outsider looking at things from a new aspect.

whereas those who are daily working in any particular line are apt to get into a groove, and to be trammelled by usage and convention. Perseverance, and a capacity for continuity in keeping to one subject, are outstanding qualities to be observed in all successful inventors. Many with brilliant ideas fail for lack of these. As has been justly said, great discoveries are never, and great inventions very seldom, the work of a single individual. Both are usually the result of numerous separate contributions by different workers, who are often simultaneously in pursuit of the same object. With regard to inventions more especially, there are periods when certain definite advances are, so to speak, in the air. In such cases many persons are working at the same problem at the same time, and it is sometimes very much a question of luck who it is who first arrives at a successful solution. It is for this reason that patent cases in the Law Courts often turn upon what lawyers term "the state of the art" at the moment. Instances of concurrence of this nature are numerous, as when Morse, Wheatstone, and Cooke were all simultaneously engaged in rendering practicable the electric telegraph. Similarly, Graham Bell and Elisha Gray were almost neck and neck in the invention of the first practical telephone.

The fact is that, at certain periods, the general state of progress, both in pure and in applied science, renders particular inventions possible, with the result that a number of persons gifted with the necessary imagination almost simultaneously attack the problem. In such cases if one individual inventor had not succeeded, it is probable that another would have done so, though perhaps in some slightly different manner.

For these reasons in all these cases it is very difficult, if not impossible, justly to apportion the credit. The public and the press usually award it all to the individual who makes the first practical and commercial success, being entirely ignorant of all the previous stages that have led up to the final result, and oblivious of the fact that, without the vast amount of previous research by other workers, the final inventor would never have had the data wherewith to achieve what he did.

On the other hand, a contrary and equally mistaken view is not seldom taken by the workers in pure science, who, absorbed in the intricacies of their own achievements, are prone to underrate what the actual inventor accomplishes, usually by slow degrees, and with infinite pains and patience. They further do not understand what a long step there is between the mere idea and the worked-out invention, and how much labour, practical ingenuity, and perseverance, and also how much money an invention usually requires to make it successful, and to get it taken up industrially. Indeed, this last-mentioned commercial operation is frequently the most difficult of all to bring about, particularly as it is not common for inventors to be good men of business.

The history of particular inventions is frequently instructive, and a good instance is that of wireless telegraphy, which is comparatively recent, so that we know all about it, and can follow accurately each single step in its development.

It moreover shows how pure and applied science are indissolubly interwoven, and how the one is dependent upon the other.

According to modern views, enunciated in the first instance about the year 1807 by Thomas Young, light consists of undulations or wave motions in a hypothetical ultra-material substance, known as the ether, which is supposed to fill all space, permeating the solid earth, the planets, the stars, and all material objects, and reaching to the utmost limits of the universe. Just as sound is known to be a wave motion in the air, so light is believed to be a wave motion in this hypothetical ether. About the year 1870 James Clerk Maxwell, Professor of Physics at the Cavendish Laboratory at Cambridge, chiefly by mathematical reasoning, showed the close connection between electricity, magnetism, and light, by demonstrating that all three could be explained on the basis of motions and stresses in the ether. Thus, according to Maxwell, light was an electro-magnetic phenomenon, and consisted of disturbances in the ether of exceedingly short wave length, whereas longer waves and stresses in the same medium explained the phenomena of electricity and magnetism.

As mentioned, Clerk Maxwell's discovery lay purely in the land of theory, discovered mathematically, and he attempted no experimental proof. Some twenty years later Heinrich Hertz, by a series of most beautiful experiments, proved the truth of Maxwell's theory. By means of suitable apparatus he first of all created electro-magnetic waves, and then with other apparatus he detected them, showing that they could be reflected and refracted, and, in fact, obeyed all the laws with which light is known to comply. Indeed, so completely was this accomplished, that, on hearing of it, Lord Kelvin exclaimed

that Hertz had annexed the whole science of optics to the domain of electricity.

Up to this stage nothing in these investigations had hinted even in the slightest degree at any useful application. Neither Young, nor Maxwell, nor Hertz, was moved by any other ambition than a curiosity to explore the nature of things. On the other hand, had it not been for their labours, what was to follow could not possibly have occurred.

Hertz died young, almost immediately after making the experiments to which allusion has been made, but his work was taken up and largely extended in this country by Sir Oliver Lodge. Hertz's experiments had been on an exceedingly small scale, while Lodge employed, for creating his waves, methods which gave a much greater power; moreover, as a detector of these waves, Lodge used an exceedingly delicate instrument, which he christened the coherer. This was due to a discovery by Branley, of Paris, who also was investigating nature without any ulterior utilitarian aims.

Lodge, no doubt, was impelled by similar motives, but having a practical mind he threw out the suggestion that the Hertzian waves might possibly be employed for signalling. Indeed, he went so far, at a lecture which he gave at the Royal Institution in 1894, as actually to ring a bell by this means from one end of the building to the other, through the thickness of several partition walls. In the same year, at the British Association meeting at Oxford, he transmitted similar signals over yet greater distances.

These experiments of Lodge led several persons to consider whether the method was not applicable to telegraphy, but nothing practical was done until Mr. Marconi, who was acquainted with the work of both Hertz and of Lodge, and was impressed with the possible commercial value of the idea, came upon the scene, and with great skill very soon showed that it was feasible by Hertzian waves to telegraph across the Channel, and even over much longer distances.

The rest of the history of wireless telegraphy, very interesting though it is, does not concern us here, for what I wish to impress upon you is how, in this instance, as in many others, researches and experiments in pure science, which, so far as their authors could see, showed not the faintest sign of any practical application, led in time to inventions of the greatest possible public utility. Many years elapsed between the researches and theories of Young and Maxwell, the experiments of Hertz, and the advent of practical wireless, and, when it came, all the three original investigators were dead; yet, unless these three great men had evolved their brilliant ideas and worked them out as they did, wireless telegraphy had never been. How difficult it is for the unitiated to realise the importance and the practical potentialities of some discoveries in physics at the moment of their birth, may be made plain by a few words about the remarkable developments that have taken place during the past few years in that department of science known as molecular physics. Up to comparatively recently the theory of the atomic structure of matter, and the idea of the indestructibility of the atom, that smallest material particle that was thought possible to exist, still held its own. First enunciated more than two thousand years ago by the Greek Democritus, developed later by another Greek philosopher, Epicurus, and popularised by the Roman poet Lucretius in his celebrated poem, "De Natura Rerum"—concerning the nature of things—this theory of matter was put on a proper scientific basis by the English chemist, Dalton, rather more than one hundred years ago. Quickly following the discovery of the X-rays by Professor Röntgen in 1895, and of radioactivity by Professor Becquerel a few months later, came a most surprising development, indeed one of the most remarkable in the whole history of science. Mainly owing to the labours of Sir Joseph Thomson and his Cambridge school of experimenters, starting from the previous researches of Sir William Crookes, we now know that the atoms, once called the ultimate atoms, so far from being the indivisible entities as was once thought, are, each individual one of them, something very like a complete solar system, comprising a positively electrified sun or nucleus and a number of negatively electrified electrons or planets. More than this, though the whole atom is so small that it is quite invisible to the most powerful microscope, and that it would take at least three million atoms, perhaps ten or twenty times as many, set close together in a straight line, to cover a single inch, the constituent electrons are so much smaller that, though contained within the compass of the atom, they are as distant from one another, relatively to their size, certainly as are the earth and the moon, and possibly as the sun and the planets. The imagination reels at such an illustration of the microcosm of the infinitely small, just as it reels at the macrocosm of infinitely large astronomical

space and its population of innumerable stars; but in nature, as has been truly said, the adjectives large and small have no meaning. In nature there is nothing absolutely great, and there is nothing absolutely little. Whether it be a matter of the dimensions of space or of the lapse of time, all is relative. To us humans, space is measured in terms relative to the dimensions of our bodies, time in periods relative to the duration of our lives. To us things appear large or small, periods long or short, but these are appearances only and have no absolute reality.

Now to those who have not studied the question all this must seem very remote from the practical politics of applied science, such as we make use of in our daily life. But it is not so, for it is to these almost infinitely small negative electrons that we owe the Röntgen rays. When propelled at the incredible velocity of something about fifty thousand miles per second, which they attain under electrical stimulation inside a Crookes vacuum tube, and caused to bombard a piece of metal, they create these rays in much the same way that the bullets from a machine-gun may rattle on a target and thus create sound. The Röntgen rays themselves are a description of light, which, until artificially produced by man in the manner described, had never been observed in nature, and, indeed, had perhaps never previously existed in the whole history of the universe. Their practical utility is, however, now universally realised, and in surgery and medicine they are in everyday demand.

Now, not only have these abstruse and seemingly quite academic discoveries about the electrical structure of the atom, and the properties of its constituent parts, brought about great improvements during the last few years in the design and use of Röntgen-ray tubes, but they have also borne practical fruit in other directions, as, for instance, in what is to-day much the most sensitive and reliable apparatus for receiving wireless telegraph signals. Their further utility, moreover, is just now beginning to make itself apparent, and quite recently they have been applied by Sir Joseph Thomson to an entirely novel form of chemical analysis, the possibilities of which it is as yet too early to estimate. Anyway, we see how in a space of only about twenty years, discoveries of apparently purely academic interest, in perhaps the most abstruse of all lines of scientific investigation, are already beginning to be usefully applied. We see how the function of science to be utilitarian obtains just as much in the case of highly recondite investigations, as in those that are more simple and in which the practical applications are more obvious.

An interesting question is what manner of men they were who made our great scientific discoveries, and what were their vocations or professions in ordinary life. To go into this fully is beyond the time at my disposal, but the following information with regard to the authors of a few of our most famous discoveries is instructive, especially in view of present-day educational controversies. An outstanding feature is that many of them had no professional connection with science at all, but were amateurs pure and simple. Among these may be mentioned Robert Boyle, the famous discoverer of the law of the expansion of gases, who was a landed proprietor educated at Eton, and has been described as "the father of chemistry and brother of the Earl of Cork." Henry Cavendish also, who discovered hydrogen and the composition of water, and did much original work in electricity, besides devising the celebrated Cavendish experiment for ascertaining the weight of the earth, was a pure amateur, being the grandson of the second Duke of Devonshire. He was very eccentric and very rich. Sir William Herschell, the famous astronomer, was by profession an organist and a teacher of music. Priestly, who discovered oxygen, was a Presbyterian minister. Dalton, the distinguished chemist who elaborated the atomic theory, was an assistant schoolmaster. Benjamin Franklin, who with a kite drew electricity from the clouds and thus established the identity between electricity and lightning, was a self-educated printer. Benjamin Thomson, afterwards Count Rumford, who contributed considerably to the theory of heat, began life as an assistant in a store. Franklin became United States Ambassador to England, while Rumford reorganised the Kingdom of Bavaria, and the pair are, perhaps, the only politicians—or, perhaps in their case, one ought rather to say statesmen—who ever contributed anything of value to science. James Prescott Joule, who was the experimental founder of the great theory of the conservation of energy, and who first determined the mechanical equivalent of heat, was likewise an amateur, being by profession a brewer.

Others were of the medical profession, as the famous Dr. Gilbert, of Colchester, physician to Queen Elizabeth, whose works on electricity and whose book, "De Magnete," are a monument to his industry and discernment. Thomas Young, the great protagonist of the luminiferous

ether and of the undulatory theory of light, also was a doctor. Sir Isaac Newton, on the other hand, was a student, and afterwards a professor, of Cambridge University, and finally Master of the Mint. Sir Humphry Davy and Faraday both made their great names at the Royal Institution, where they enjoyed facilities for experiment, which one would like to see greatly multiplied elsewhere. Both were of humble origin, Davy being the son of a wood-carver, who became assistant to a surgeon; and Faraday the son of a blacksmith, and a bookbinder's apprentice, who had the good fortune to attract Davy's attention and to become his assistant, and afterwards his successor. It is noteworthy that but few of these great men had the advantage of early scientific training.

The case of some of the world's greatest inventors is also interesting. James Watt began life as a mathematical instrument maker. George Stephenson was a colliery fireman who only learnt reading, writing, and arithmetic after he was grown up. Arkwright, the great inventor of cotton-spinning machinery, was a barber. Daguerre, one of the principal inventors of photography, a scene painter. Sturgeon, the inventor of the electro-magnet, was a private soldier, and carried out his earlier experiments within barrack walls. Morse, of telegraphic instrument and code fame, was a painter and sculptor. Alexander Graham Bell, the inventor of the telephone, a teacher of the deaf and dumb. David Hughes, the inventor of the type-printing telegraph and of the microphone, a professor of music. Edison, a railway newsboy, practically self-taught. William, afterwards Lord, Armstrong, the inventor of hydraulic power distribution, and celebrated for his gun, a practising solicitor till he was thirty-five years of age.

All this goes to show that, as already stated, inventors are born and not made; and that, at any rate in numerous cases, genius can dispense with teaching from outside. In fact it is not for men such as these that more education in science is to-day wanted, but rather for our masters, the politicians, the directors of public affairs, and the Government officials.

It is impossible to study the history of civilisation without recognising that scientific research and invention, with their innumerable and incalculable actions and reactions, constitute the soul of industrial progress. Consequently, if this progress is to be maintained, every inducement must be provided to encourage those who are capable of carrying on the work. Since the commencement of the world it is not to the masses but to the few exceptional individuals that all great advances have been due, and it is greatly to be deprecated that politicians who must, or, at any rate, should, know better, continue to flatter the so-called working-man by telling him that he alone is the creator of wealth. To those who know the facts such a suggestion is, of course, absurd. Still, it is highly necessary that the masses should be educated to learn that unless those who have the requisite capacity are afforded the necessary leisure and facilities to work at research and invention, industries can neither be developed nor even maintained in the face of the world's competition, and that the working-man himself will be the principal sufferer from the resulting stagnation and decay.

We hear at present a great deal about the avarice of capital and the extortionate profits of monopolists and patentees, and still more about the due reward of labour. At the same time but little is said as to the encouragement of ability, though the latter is really of paramount importance to the nation. For, whatever may be the case with capital, ability, if not encouraged at home, can easily take wings and fly to other lands, where it is better appreciated. Then home industries will languish, employment diminish, and where will labour be?

It is unfortunate that in this country of late years it has become a fashion to consider the making of large profits as almost a crime, for the working out of many industrial scientific processes and inventions can only be accomplished by great and prolonged expenditures, and the risking of vast sums of money, such as only very rich persons or companies can afford. The history of the fine chemical trade in Germany for some years before the war is a good case in point. Here very large sums were in some instances spent on the development of special processes. In many cases the money was lost, but the few speculations of this nature that succeeded recouped all that had been spent on the others, a single product in some instances bringing in an enormous net annual profit. This, again, enabled other similar problems to be attacked. With our system of taxation—income tax and super tax, and now excess profits tax in addition, and the jealousy and outcry that the making of large profits engenders—it is very difficult to arrive at such results in this country, and this undoubtedly is one of the main reasons for our backwardness in diverse directions. A remedy should be found in exempting from taxation all money spent in new scientific

developments. Otherwise, with stinted resources, we cannot expect to maintain our position.

There are two methods by which people acquire wealth. In one case they transfer other people's wealth out of these people's pockets into their own; in the other case they actually create wealth that did not previously exist. Though the first method may often be quite legitimate and even beneficial, it cannot, of course, be compared in importance with the second, for whosoever really creates wealth, not only enriches himself, but adds to the resources both of his own country and to those of mankind. Now one of the functions of science is to create that best of all descriptions of wealth, increased productivity, which it does through discovery and invention, and the enhanced command that man thereby obtains over nature. Thus the invention of the steam-engine by James Watt, and the three or four other men who were associated with him in that vast development, must have increased the wealth of Great Britain and of the world by many hundreds, if not thousands, of millions sterling. The Stephensons and their associates in the invention of the locomotive and its application to railways also cannot fall very far behind in this respect, while other inventions great and small all operate in a similar manner. Both those who make discoveries and those who make inventions are therefore in general well worthy of their hire, and in both categories it is seldom that they receive as remuneration for their work more than the merest modicum of the wealth that they create. This is a point that should not be forgotten, especially in these socialistic times, when much of the popular political teaching tends to uphold an opposite view.

This brings me to another point in connection with invention, and that is the injustice and the inexpediency, from a public point of view, of the present system whereby the Patent Office makes a large annual profit out of the fees paid by inventors. There might possibly be some justification for this were the money thus obtained spent on scientific education, on scientific libraries, or on some other object that would further invention and discovery. The money is, however, merged in the ordinary revenues of the country, and thus becomes a veritable tax on brains. It is, moreover, a tax on the cerebral activity of a class of men who are usually by no means overburdened with wealth. Though all inventors are fortunately not driven by poverty to such expedients as Palliser the potter, who actually had to burn his household furniture in order to provide heat for his furnace, still the majority of inventors are undoubtedly poor, and find the cost of protecting their inventions by patent, and still more of maintaining these patents when granted, a considerable strain upon their finances. The truth of this may be seen by the frequency with which patents are dropped merely in order to save the renewal fees, and the patentee in some cases deprived of profits to which he is justly entitled. Herein lies a possible and very desirable reform which this Society might perhaps do something to bring about.

We shall, however, never get justice done to science by the Government and its departments until some knowledge of science is made a compulsory part of the curriculum for the training of the Civil Service, and an important item in the entrance examinations. Only in this way shall we get the departments filled by men who realise what science means, and how it lies at the root of all material progress. There is an idea afloat in the political world, as also in the bureaucratic mind, that no man can at the same time be a master of science and a good administrator or organiser, either in public or commercial affairs. This idea probably originated from observation of scientific men of the scholastic and professorial types, whose training has been mainly directed to the art of teaching, and who have never had much opportunity of developing their faculties in the administrative sphere. To show, however, how false is the assumption, it is only necessary to mention two such names as those of Benjamin Franklin and Count Rumford, both of whom were consummate men of science and did very valuable original scientific work, but were also both prominent men of business and managed great political undertakings with remarkable success. Or, if we come to more modern times and turn to captains of industry, there are, without going out of this country, and only to mention one or two, such men as Joseph Whitworth, Henry Bessemer, William Armstrong, and Andrew Noble, all of whom had high scientific gifts and knowledge, and also were very successful in the organisation and administration of large industrial enterprises. Indeed, for any business employing technical methods, the ideal chief must necessarily be a man of scientific attainments, as it is only such a one who can properly weigh the pros and cons of the propositions put

before him by his technical staff, while what is even more important, it is only such a chief that can command the real respect of his employees, who will never have complete confidence in, or a proper veneration for, a leader whose scientific and technical knowledge and experience is in the aggregate less than their own. These considerations, of course, apply equally to Government departments which deal with scientific questions as to industrial undertakings carrying on technical processes or manufacture.

In obtaining Government support for the promotion of applied science, it is most necessary to beware of political interference.

The dangers that arise from this may be seen from the history of one or two typical industrial applications of science during the last century. Take, for instance, the application of mechanical power to road locomotion. In the period covered by the years 1820 to 1836 this made rapid strides, and towards the close of the period many steam-coaches were maintaining regular services between various centres in different parts of the country. In this, England was many years ahead of the rest of the world and a new, and what promised to be a very profitable industry was being developed. Parliament, however, at the instance of rival interests, passed hostile legislation which absolutely shut the whole movement down, and automobilism in this country was completely crushed, not to be heard of again for more than fifty years. When, moreover, a new beginning was made, the fresh start did not take place in England, its original home, where it was prohibited by law, but in France where legislation was more enlightened. In this way, owing entirely to the politicians, we lost an opportunity of becoming pioneers throughout the world of a completely new and what proved to be a gigantic industry, which might have brought to our manufacturers much wealth and to the working-classes much lucrative employment.

Or, to turn to another case, take the history of electric lighting and of the supply of electric power. Here again the development of a new scientific industry was greatly impeded by Parliamentary action. In 1882 this country was as far advanced in everything pertaining to the application of electricity as any other country on the globe. Indeed, many of the developments in this branch of science were peculiarly British, having originated in this country. Again, Parliament intervened, and with a mistaken idea of protecting the consumer from the dangers of monopoly, so effectually strangled the whole movement that for six years there were practically no consumers at all, as the conditions imposed on undertakers were so onerous that no one would risk the money required to institute a supply. In 1888 the political powers that were, realising their mistake, made some legislative amendments that enabled a start to be made; but it was then too late, for other countries had got ahead, and even then the electrical industry was still hampered by artificial conditions, some of which endure to the present day, with results that have been very inimical to proper development. There are other similar instances, such as the telephone, in regard to which the politicians have interfered to the detriment of progress.

To a Society such as this, whose object is the encouragement of the arts, science is mainly interesting from its pre-eminent value for purely materialistic ends, and it is therefore from this point of view that I have endeavoured to give some account of its functions. It must not, however, be supposed that science has not also a very high value, from an ethical standpoint. As Adam Smith wrote in his "Wealth of Nations" a century and a half ago, "Science is the great antidote to the poison of superstition"; moreover, science is, so far as the limitations of the human intellect will permit, a search for absolute truth. Accuracy is its foundation stone, acute observation and strict logic its most powerful agents. These have all an educational value of the highest importance. The study of nature and the pursuit of knowledge have, in addition, an elevating influence, and produce a breadth and a strength of mind that rise superior to material environment. This is well seen in the blameless lives of the great masters of science, and in the way that many of them sacrificed everything to their work. Some encountered persecution and even martyrdom for their ideas, and met their misfortunes with a fortitude quite equal to that shown by other men for their faith. Among the functions of science we must not therefore forget its moral power.

After delivering the address, the Chairman presented the Society's medals which were awarded for papers read during last Session.

At the Ordinary Meetings:—

Francis A. Hocking, B.Sc., Pharmaceutist to the London Hospital, "The War and Our Supply of Drugs."

SIR C. ARTHUR PEARSON, Bt., Chairman, Blinded Soldiers and Sailors Care Committee, "The Blind Sufferers from the War and their Future Employment."

LESLIE URQUHART, "The Economic Development of Russia and Britain's Interest therein."

In the Indian Section :—

JOHN AITON TODD, D.L., Professor of Economics, University College, Nottingham, "The World's Cotton Supply and India's Share in it."

In the Colonial Section :—

CAPTAIN PHILIPPE MILLET, Colonial Editor of *Le Temps*, "The Problems of French North Africa."

SIR HENRY TRUEMAN WOOD said the pleasant duty had fallen upon him of proposing a vote of thanks to the Chairman. He accepted that duty, and felt it a very great compliment to have been asked to undertake it, but he did so with a little regret, because Sir Dugald Clerk, the immediate predecessor of Mr. Campbell Swinton, was to have proposed the vote of thanks, but he had unfortunately been called away. The Chairman of the Council had, under the Society's rules, to address the Society at the opening meeting, originally mainly with the idea that he should indicate to the members the programme of the Society for the session and the course of its work during the year. For a good many years the Chairman of the Council had gone beyond that limited scope, and, instead of merely saying what the Society was going to do during the next six months, he had preferred to deal either with some special detail of the Society's work or with the general progress of the Society, taking its work as a whole and its future as a whole. The result had been that the Society had had a long series of most valuable and instructive addresses from its past Chairmen, some of the most distinguished men of their time. Amongst those addresses certainly that of the late Chairman of the Council, Sir Dugald Clerk, took a very high place, and the present Chairman therefore had to compete with work of a very high standard. He was sure, however, all the Fellows would agree that the brilliant survey of human progress with which Mr. Campbell Swinton had delighted them that afternoon was as worthy to take its place in the records of the Society as the addresses of any of Mr. Swinton's predecessors. Sometimes lately he had been inclined to think that a malignant influence was diverting scientific progress from its proper course, and causing it to devote itself to appliances and instruments for causing the greatest amount of misery to mankind, and the greatest anguish to individual men, instead of confining itself to its proper function of increasing human welfare and human happiness. There was every reason to believe, however, that science would soon get back to her proper duties, and he thought the news which had just been published of the great success that had attended the British Armies in France brought that happy period definitely nearer. To-day one might look forward to an earlier conclusion of the war than could have been hoped for yesterday, and he regarded it as a happy inauguration of the Society's session that that good news should come when the Society was actually beginning its work for the current session. The Chairman had given the members an example of his intellectual capacity, but beyond that he was, as many of those present knew and all his friends realised, a most admirable man of business; and he felt a little pride in the fact that the last service he rendered to the Society as Secretary was to convince Mr. Campbell Swinton that it was his duty to undertake the Chairmanship. He was very glad to say that Mr. Campbell Swinton's objections were overruled, with the result that the Society had a most excellent working head for the coming year. It was possible that his resignation from the Secretaryship would throw a little more work upon the Chairman, and partly for that reason it was essential that the Society should have a good man of business at its head, the Chairman of the Council being of course the practical head of the Society during his term of office. Such a man the Society had obtained, and he congratulated it on that fact. He also assured the Fellows that they might be perfectly well satisfied with the head of their executive staff. He had watched Mr. Menzies very carefully for the past nine years during which they had worked together, and he had tried to train him so that he might undertake the post of Secretary when he (Sir Henry Trueman Wood) had to resign. The Fellows might fully rely on Mr. Menzies' capacity and ability to carry on the work of the Society in the way in which it should be carried on. He begged leave to propose a very hearty vote of thanks to the Chairman, and asked those present to congratulate the Chairman, by their vote, upon the address he had just delivered, and to realise that they had the best man they could wish to have to carry on the very important work of the Society.

HIS GRACE THE ARCHBISHOP OF CANTERBURY, in seconding the motion, said that when he entered the room, anxious to hear what was to be said by one whom he had known from his birth, he little thought he would be called upon to do what was a most unwonted thing for him—to say a few words to scientific men upon a scientific paper. He was comforted, however, by the fact that the Chairman had reminded them that some of the best and most useful work that had been done in connection with science had been carried out by people who knew nothing about science; they were merely amateurs who had happened by accident to discover something of scientific importance. Therefore, those who had to confess themselves unscientific down to the soles of their boots were not to be

left without hope or without opportunity. Mr. Campbell Swinton's address had been extremely interesting to him, and he was sure must have been so to all those present that afternoon. He personally had known Mr. Campbell Swinton from the day of his birth till the present time, and had watched him adding laurel to laurel, and acquirement to service and service to acquirement, right through those years. The present address seemed to him a masterly piece of work, because it was one of the most difficult things in the world for a person who was conversant with a particular field of some great subject to traverse the whole subject in a large and general way without boring those who were not as expert as he was in its intricacies. No one could have found a single sentence in the address tedious or boring. On the contrary, Mr. Campbell Swinton had started two or three trains of thought which could be followed up, not in connection purely with the definitely scientific aspect which he gave them, but in a larger way. All that the Chairman had said about the contrast between the progress of science to-day and its progress at other periods, and the question whether or no our boasted progress had really got us as much further as we supposed in the pursuit of human knowledge and human attainment in the highest sense of usefulness, seemed to him particularly interesting at the present time. Those who had read the notable book published within the last few days, Lord Morley's "Reminiscences," would have noticed how he touched upon the very thoughts which Mr. Campbell Swinton had touched upon in his present address, as to whether or not we were now really in a better condition, in consequence of all our science and knowledge, than people were, say, in the days of the Antonines. Lord Morley treated the subject in a masterly way, and Mr. Campbell Swinton had given a striking illustration of the truth of the thoughts which Lord Morley threw out as a man of letters and a man of affairs. The other day he was asked whether he realised that when Julius Cæsar came to conquer Britain he walked here. There seemed no doubt that Julius Cæsar did not ride on a horse or come in a litter, and it puzzled people a little to think of the contrast now in the speed of travelling, and led them to wonder whether the world was better or worse for the expedition with which things could be carried out. That was a matter which offered a large field for thought. Mr. Campbell Swinton suggested another thought, which was one of great usefulness, by showing how mistaken it was to regard the acquisition of a certain piece of knowledge merely from its obvious utilitarian standpoint, and how the utility came in later—if the knowledge was there the time would come when it would take its place and find its use. Another thought was suggested in the address by the way in which Mr. Campbell Swinton dealt with the problem of the contemporary study of great questions, and contemporary—almost synchronous—invention by different men. It was not always that an exactly similar course of study was being pursued by those different men. Some instances given in the address, and certain others with which everyone was familiar, showed that men, following quite different routes, accidentally, it would seem, or by some extraordinary coincidence, arrived at the same practical conclusion at the same time, and the world was thus enriched by an invention which it was extremely difficult to allocate to a particular individual. He desired once again to express his appreciation of Mr. Campbell Swinton's address, and to rejoice in the thought that amateurs from outside might come in and touch on scientific matters without necessarily doing them harm, and sometimes even doing them good.

The resolution of thanks was put to the meeting by SIR HENRY TRUEMAN WOOD, and carried with acclamation.

THE CHAIRMAN thanked the mover and seconder of the resolution for their flattering remarks, and all those present for the appreciative way in which they had received the motion. He had just been thinking how sometimes circumstances altered cases. That afternoon he had very properly deplored the loss of literature that occurred owing to the burning of the great Library at Alexandria, but he could carry his mind back to a time when his sentiments were somewhat different. He could remember when it was part of his daily task to learn some Propositions of Euclid, and he remembered that at that period he did not deplore the loss of many of the books of Euclid—it was a matter of great satisfaction to him. That satisfaction was only tempered by a certain amount of fear that before his course of geometry had finished perhaps those other books might be found.

THE RESTORATION OF FORESTS DEVASTATED BY THE OPERATIONS OF WAR.

In an article on this subject in *La Nature*, M. A. Jolyet, Professor at the École Nationale des Eaux et Fôrets, says that the North-East of France is a well-wooded region, and it is natural that numerous forests should have suffered as a result of the operations of war. However, though the damage incurred may have been great, it does not follow that the forests must necessarily be destroyed.

A forest is not merely formed by the sum of the plants living therein, but also by the forest soil, or primitive soil modified by the existence of the forest, and by the sum of the plant and animal life there developed. The "état boisé" (wooded state) so produced represents a valuable capital, and it would be a serious mistake not to utilise it as soon as possible, for this state or condition, though surviving the destruction of the forest population, does not last for ever.

There are two methods of regenerating a forest in these conditions: one natural and the other artificial. The former is not profitable, being too long, whereas the interest of the owner lies in obtaining commercial timber from his forest as soon as possible.

The first point then to establish in restoring a forest damaged by war is whether the injured trees are definitely broken or merely bruised. In the first case they must be cut down level with the ground and, provided the species is a deciduous one and not too old, new shoots will then emerge from the stump. On the other hand, if the tree is a conifer, no shoots will be formed, but by cutting down the tree the danger of encouraging insect parasites will be avoided. In the second case also felling is almost always advisable, for a mutilated tree is not likely to produce healthy wood.

As a result of the felling, gaps of greater or less extent will occur. These it will be necessary to till up by means of appropriate species: (*a*) encouraging the natural reconstruction of the forest with wild species, or at any rate not impeding this by an excessive amount of cover—(*b*) capable of furnishing within a short period good marketable timber, the sale of which will enable the proprietor to put back the forest in its original state.

Next, the two following cases must be considered:—

(1) *Gaps of large extent.*—When the removal of damaged plants leaves a very big gap, it is advisable to plant, not merely a temporary, but also a robust species with light shade in order to allow the reconstitution of the original species (oak, hornbeam, maple, ash, fir, etc.). The majority of pines fulfil these requirements—the Austrian pine is particularly adapted to a thin chalk soil; in sandy soil, on the other hand, Scots pine does best. *Pinus Banksiana*, Lamb., in spite of the small value of its wood, is also recommended on account of its great hardiness, which favours a quick recovery. As these species all require light, the plantations must be fairly thin, the trees five to ten feet apart.

Clearings must then be made in succession, and in this way, while obtaining an easily marketable product, the forest will eventually be completely reconstructed and rendered capable of again yielding marketable timber in its turn.

(2) *Gaps of very small extent.*—When the gap left by the removal of the plants is not above twice the height of the surrounding trees in size, the use of pines, which require a particularly large clearing, is not possible. However, as the object is to plant trees capable of early utilisation, there are other species of conifers answering to this requirement, and among these the fir and spruce are preferable. Though they give a very thick shade, the pyramidal shape of their summits will give the minimum of inconvenience to the surrounding trees, especially to the deciduous species. The fir is most advisable from the cultural point of view and the spruce from the commercial standpoint. At the same time, this would be the best way to establish the fir in forests of deciduous trees, and could only add to the value of the forest as a whole.

The writer also recommends the white fir (*Abies concolor*, Lindl. and Gord.), characteristic for its hardiness and rapid growth. The wood, however, is mediocre, though perhaps not more so than that of the fir cultivated at a low altitude. The Douglas fir (*Pseudotsuga Douglasii*, Carr.) might also be recommended, as it furnishes a first-class wood and grows rapidly; but there are doubts as to its hardiness. In this connection the tested Colorado variety might be borne in mind, though it grows less rapidly.

If, finally, other deciduous species are preferred to the conifers mentioned above, one might use for the big clearings birch and false acacia instead of pines. On the other hand, in the case of the small gaps, beech, or better, ash, might be planted instead of firs, and especially sycamore, which can do with a fairly poor amount of light.

THE CORAL INDUSTRY OF JAPAN.

The coral industry of Japan has received a strong stimulus from the European war. Previously this country exported about half of its crude coral to Italy, where there was a steady demand for it on account of the practical exhaustion of the coral beds in the Mediterranean. Skilled Italian workmen carved the coral into the various forms demanded by the fashions and tastes of the Occident. As Italian-carved coral it was sold through Dutch distributors to the whole world.

Since the outbreak of the war, writes the United States Vice-Consul at Nagasaki, there has been a natural decrease in the demand for carved coral, but the chief difficulty encountered in supplying the market has been that of making direct shipments of crude coral from Japan to Italy. Usually it has been necessary to make one or two transhipments *en route*, with incidental expense and delays. This produced a decrease in the quantity exported to Italy. The resulting situation caused the Japanese to fall back on their own resources in undertaking to absorb the surplus of crude coral left in the home markets.

The Italian dominance in the coral industry has been due to priority in the field and to a knowledge of the styles of carving in demand among Occidental buyers. Japan has been handicapped, not by a lack of skill in carving (for it is in the domain of small carvings that Japan has been recognised as supreme), but by failure to have an up-to-date knowledge of Occidental fashions and tastes. It was only necessary to teach artisans already skilled in carving ivory and wood to work with a new medium. But the Japanese have not ventured to produce any manufactured coral except what was suited for sale in the home market. This has been practically limited to beads and netsuké (small buttons

used as ornaments on the strings of tobacco pouches). The beads are of all sizes and are sold in strings of three or four inches in length, as hair ornaments for women. Large single beads, from one-half to three-quarters of an inch in diameter, are used as the heads of large ornamental hairpins much in favour among Japanese women. In the manufacture of coral beads the Japanese are recognised as the equals, if not the superiors, of the Italian workmen.

A realisation of the opportunity created by the war for Japan to take the place of Italy in the production of carved coral has led the Japanese Government, through the marine experiment stations, to undertake the training of artisans in the carving of coral for sale in Europe and America. It is hoped by this measure to increase the value of coral exports from the £100,000 received each year for the crude coral exported, to £7,000,000 for exports consisting entirely of carved coral.

A special agent of the Imperial Fisheries Bureau is detailed to assist in the development of the industry in the Goto district of Nagasaki Prefecture, where new coral beds of exceptionally high productivity were recently discovered. He also has charge of the instruction of the apprentices, now about twenty in number, in the carving of coral. After the Goto district, the Provinces of Tosa, Satsuma, and Miyazaki follow in order of importance as centres of the coral industry.

The coral beds are worked by divers in the employ of a master diver, who receives the take as it comes in, grades it, and when a sufficient amount has been obtained, asks for bids on the lots of each grade. Representatives of the leading exporting and wholesale firms are always at hand during the season when the best coral is taken, to inspect the take and proffer bids. The total annual take is about 65,000 lb., valued at £140,000.

The colour of the coral has a great deal to do with the value placed upon it. The most expensive is "bokó," a pale quince colour. Single beads of this colour, suitable for manufacture into ornamental hairpins, bring from £2 to £10 each. The next colour in value is pink, followed by white, light red, and dark red.

OBITUARY.

Samuel Charles Phillips.—Mr. S. Charles Phillips, head of Messrs. S. C. Phillips, proprietors of the *Paper Maker* and other well-known trade publications, died, after a short illness, at his residence, Greenbank, Beaconsfield Villas, Brighton, on October 9th, in his fifty-fifth year. He was a recognised authority on the paper, board, and pulp industries, both at home and abroad, and he keenly interested himself in the search for, and utilisation of, new paper-making materials. He read three papers before the Society, namely: "The Use of Wood Pulp for Paper-making" (1905), "The Empire's Resources in Paper-making Materials" (1915), and "Paper Supplies as Affected by the War" (1916). He also took part in discussions at several other meetings of the Society. He was elected a Fellow of the Royal Society of Arts last year.

GENERAL NOTES.

Forest Products of Quebec.—The forests add over $15,000,000 every year to the production in the Province of Quebec. The forest reserves in this province, says the *Paper Maker*, total 107,997,513 acres. The pulp wood, lumber, shingles and laths make up the big annual production of the timber industries of this province. The pulp wood used in the province approximates a value of $4,000,000 per year. The woods used in the manufacture of pulp, to which this province adds a big annual contribution, are spruce, balsam, fir, hemlock, poplar, larch and jack pine. The pulp wood consumption in Quebec Province is the largest in Canada. The lumber production of Quebec exceeds usually a yearly value of $10,000,000. Quebec has one of the three biggest lumber, shingle and lath productions in Canada. The shingles produced in the province total an annual value of about $700,000. The lath output of Quebec exceeds a value of $225,000 annually. The total value of lumber, lath and shingles produced in the province in one year exceeds $15,000,000, a recent total being $15,758,529. About two-thirds of this total is in lumber and timber, the other third being in pulp wood, lath and shingles.

Scarcity of Coal in Havana.—According to the British Minister at Havana, a number of Cuban sugar mills are, owing to scarcity of coal, preparing to use oil fuel. Storage tanks have, in one or two instances, been purchased and installed, but things of the kind are naturally, at the moment, difficult to obtain. The cost of converting the furnaces is not serious. The railway companies are in a much worse plight through the shortage of solid fuel. The United Railways of Havana have 264 locomotives, and the cost of their conversion, estimated at 1,000 pesos for each locomotive, together with the cost of tanks and pipes, would absorb a considerable sum. There has been a good deal of prospecting for oil in the Province of Havana, and numerous claims have been registered, but so far only two wells have given actual results. The general impression seems to be, however, that the prospects are good. The output of the two wells at Bacuranco continues to increase.

LOCOMOTIVE DEVELOPMENT.—In his report for 1916, the General Manager of the South African Railways and Harbours makes the following comments upon locomotive development:—The further improvement of the locomotive boiler is a subject that has engaged the attention of mechanical engineers for some time. The superheater has added greatly to the steaming efficiency, and has neutralised the difficulties associated with the firing of large engines to maintain the pressure of steam necessary for the work required of a modern locomotive. But increased steam pressures are still desirable, and experiments are being conducted in different parts of the world with new boiler designs and other improvements calculated to develop the steaming efficiency and the steam pressure of the locomotive. That very high pressures can be raised and maintained by means of tube or pipe generators has already been established, but it has yet to be proved whether a generator of this type can be successfully adapted to locomotive practice. A generator on those lines has been designed by the Superintendent (Mechanical), Johannesburg, and inquiries are being made as to the practicability or otherwise of his proposals. The design involves a radical departure from present practice, and will require most careful investigation and consideration before further action is taken. In the experimental stage oil fuel may have to be used, but the object in view is to adapt the engine to burn coal dust, and that being so, the result of the advance that is being made in the United States with engines designed to use pulverised fuel is being watched with special interest, particularly in view of the fact that the use of such fuel eliminates fire hazard.

EXPORTS OF PRESERVED CODFISH FROM JAPAN.—H.M. Commercial Attaché at Yokohama writes that the Japanese Department of Agriculture and Commerce made efforts to develop the export trade in codfish from Japan prior to the war, and that during the last three years there has been a considerable increase in exports of this commodity to North and South America and the South Pacific Islands. Big fish are preferred for the export trade, and those caught off Horomushiro, Kurile Islands, are considered to be the best. Codfish are exported from Japan either salted, dried or tinned, the tinned variety being in greatest demand, followed by the salted. American salt is imported for preserving fish for export to America, as fish treated with Japanese salt do not satisfy the American taste.

RUSSIAN MERCANTILE MARINE.—The Canadian Trade Commissioner at Petrograd (Mr. C. F. Just) reports that with the elimination of German shipping interests as intermediaries in the seaborne trade of Russia, the Government recognises the importance of immediate measures for the development of the country's mercantile marine. Proposals having this object in view have been put forward by the Ministry of Trade and Industry in a Memorandum accompanying the estimates of that Department for 1917. Concurrently with the re-establishment and expansion of existing lines, vigorous action is recommended in connection with plans for (1) a line from Odessa to London; (2) a line from Baltic ports to Vladivostok; and (3) services forming communications between Russian and foreign ports in Europe with the estuaries of the Siberian rivers Obi and Yenisei. Special importance is attached to the creation of direct lines to America, under the Russian flag, for passenger traffic.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 26...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Lieut.-Colonel the Hon. Sir John McCall, "Land Settlement within the Empire."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. (Harben Lectures.) Dr. A. Carrel, "The Treatment of Infected Wounds." (Lecture I.)

East India Association, Caxton Hall, Westminster, S.W., 4.15 p.m. Rev. T. Davis, "The Social Evolution of India."

Geographical Society, Burlington-gardens, W., 8.30 p.m. Maggioro Cav. Filippo de Filippi, "The Geography of the Italian Front."

TUESDAY, NOVEMBER 27...Swiney Lecture, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Professor J. S. Flett, "The Mineral Resources of the British Empire." (Lecture VII.)

Sociological Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. (Harben Lectures.) Dr. A. Carrel, "The Treatment of Infected Wounds." (Lecture II.)

University of London, University College, Gower-street, W.C., 5 p.m. Professor S. D. Adshead, "Housing Problems after the War." (Lecture IV.)

WEDNESDAY, NOVEMBER 28...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Colonel M. O'Gorman, "Aerial Transport."

THURSDAY, NOVEMBER 29...Swiney Lecture, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Professor J. S. Flett, "The Mineral Resources of the British Empire." (Lecture VIII.)

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. (Harben Lectures.) Dr. A. Carrel, "The Treatment of Infected Wounds." (Lecture III.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Professor W. C. F. Anderson, "The Dead Hand in Art, Tradition, Convention and Imitation."

FRIDAY, NOVEMBER 30...Swiney Lecture, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. Professor J. S. Flett, "The Mineral Resources of the British Empire." (Lecture IX.)

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. (Thomas Hawksley Lecture.) Captain H. R. Sankey, "Heat Engines."

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CONTENTS.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers nearly four thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

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FRIDAY, NOVEMBER 30, 1917.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 3rd, at 4.30 p.m. (Cantor Lecture.) H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, "Progress in the Metallurgy of Copper." (Lecture I.)

WEDNESDAY, DECEMBER 5th, at 4.30 p.m. (Ordinary Meeting.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "Discovery and Invention" (Inaugural "Trueman Wood" Lecture). ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

HOWARD LECTURES.

The Howard Lectures on "The Shortage of the Supply of Non-Phosphoric Iron Ore," by William George Fearnsides, M.A., F.G.S., M.Inst.M.E., Sorby Professor of Geology in the University of Sheffield, have been reprinted from the *Journal*, and the pamphlet (price one shilling) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. 2.

A full list of the Lectures which have been published separately, and are still on sale, can also be obtained on application.

EXAMINATIONS.

The results of the 1917 Examinations have now been published in a pamphlet of 126 pages, folio, which can be obtained at the Society's offices, price 1*s.*, or by post 1*s.* 2*d.*

Copies have been sent to all examination centres.

The results had previously been communicated to all the candidates.

JUVENILE LECTURES.

A course of two lectures, adapted to a juvenile audience, will be delivered on Wednesday afternoons, January 2nd and 9th, 1918, at 3 p.m., by Mr. P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, on "Animal Camouflage."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

"OWEN JONES" PRIZES.

Competitions, under the terms of this Trust, have been held annually from 1878 to 1915 in connection with the National Competition of the Board of Education. This competition not having been held in 1916, the prizes were not awarded, but a special competition was held in 1917.

The Council are now prepared to offer six prizes for designs for (1) Chintzes, and other Stamped, Printed, or Stencilled Textile Materials; (2) Wallpapers; and (3) Tiles.

Each prize will consist of a bound copy of "The Leading Principles in Composition of Ornament of Every Period," from the "Grammar of Ornament," by Owen Jones, and the Society's Bronze Medal.

The competition is limited to students of Schools of Art.

No competitor may send in more than a single design for each of the above-named manufactures, but that design may be accompanied by one or two working drawings or other illustrative sketches.

A sample of manufacture executed from the design may be submitted with, or in substitution for, the original design; but every submitted work must be approved by the master or other authority of the student's school, who must also certify that the design is the work of the student sending it in, and that it has been executed since June, 1917.

No candidate who has already received an Owen Jones prize for any of the above-named manufactures can take part in the competition.

Competing designs must be sent, carriage paid, and labelled "Owen Jones Prize Competition" on the outside, to the Director and Secretary, Victoria and Albert Museum, South Kensington, S.W. (7), between June 24th and June 29th, 1918. They may be delivered by hand on any one of the three days ending June 28th.

The sender must also notify the Secretary of the Royal Society of Arts by post that the design has been sent in, and must enclose stamps or P.O.O. for the return carriage.

No special conditions are laid down as to the size or character of the drawings sent in, but the attention of competitors is drawn to the following remarks of the judges on the competition in 1917:—

"The judges think it desirable that greater stress should be laid by the students' teachers on the necessity for more attention to the technical details required in designs intended for reproduction by printing or in the loom. Very few of the designs sent in had appended to them any explanatory specification, such as is usually required for the guidance of the technical craftsman who has to put the artist's drawing into the shape necessary for reproduction."

The awards will be made by the Council of the Royal Society of Arts on the recommendation of judges appointed by them.

The Council reserve the right of withholding any or all of the prizes offered, and they will be the sole judges in each individual case of the qualifications of a competitor to receive an award.

All possible care will be taken of the designs, but the Council accept no responsibility for injury or loss.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

Wednesday, November 28th, 1917; The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Birnie, Cyril Montague, Japan.
Boyd, John St. Clair (jun.), Belfast.
Campbell, James, Saltburn-by-the-Sea.
Hirst, Stuart A., Leeds.
Humphrey, George Harold, London.
Kaye, Harry, M.Inst.Met., London.
Pitman, Archibald R. C., W.S., Edinburgh.
Roe, Humphrey Verdon, Manchester.
Voight, Howard Edward Latimer, Stanmore, Middlesex.
Warner, Frank Cloudsley ff., London.
Wiblin, Frederick Avent, Plymouth.

[Mr. G. Holt Thomas was prevented by illness from reading the paper on "Aerial Transport after the War," which he was to have given. His place was taken, at very short notice, by Colonel Mervyn O'Gorman, C.B., who, owing to pressure of work, was unable to prepare a paper in time for it to be set up in type and submitted to the Censor before the meeting.

In these circumstances it became impossible to publish the paper in this number of the *Journal*, but the usual report of the meeting will appear in the issue of December 7th.]

COLONIAL SECTION.

A meeting of the Colonial Section was held on Monday, November 26th, 1917; The Right Hon. Walter H. Long, LL.D., F.R.S., M.P., Secretary of State for the Colonies, in the chair.

The Chairman, in opening the meeting, said that during a very long Parliamentary career he had always been profoundly interested in the question of the settlement of citizens from this

part of the Empire in other parts of the Empire. When he first began to take an interest in that question there was a great deal of opposition to anything of the kind. People looked upon the transference of a man's home from the United Kingdom to some distant part of the Empire as a form of exile, and they resented and resisted it. He deprecated any system of compelling or bribing able-bodied citizens of the Empire, who were wanted in the home country, to leave that country. On the other hand, it was not desirable to try to control the wishes and the movements of free citizens, and if men or women desired to transfer their energies and their intelligence and their muscles to another part of the Empire, they should not be prevented from doing so. If they wished to go, everything possible should be done to ensure their leaving this country and entering the land of their choice under the most satisfactory conditions. All the pitfalls that often beset them on the way should be got rid of; their departure from this country should be made easy for them, and their reception on the other side secure, so that they would not fall into temptation and danger, but have a fair start from the beginning. He had personally watched, in more than one part of the Empire, the work done in that way by the Salvation Army, and he had the greatest admiration and gratitude for the service that body had rendered to the Empire by the care they had taken of those people who had gone from this part of the world to other parts of the British Dominions. It was customary to talk of "emigration," but he hoped the time would soon come when that word would be replaced by the word "migration." There was in reality no difference between the movement of a man from Cornwall to Caithness and the movement of a man from the United Kingdom to Australia or Canada or Newfoundland or South Africa, or any other part of the British Empire. He hoped that, whatever changes might be effected, and whatever alterations in our policy might be made, everything would be done to ensure that those who desired to leave the country of their birth, the United Kingdom, should have every opportunity offered to them to go to another part of the same Empire, and there continue the work of Empire-building.

The paper read was—

LAND SETTLEMENT WITHIN THE EMPIRE.

By Lieut.-Col. the Hon. Sir John McCall, M.D., LL.D.,
Agent-General for Tasmania.

The subject of the paper I am about to read is one that demands the early attention of the people of the British Empire. The Empire is large, representing about a quarter of the land of the world, and parts of this are very sparsely populated, while much of it is uninhabited. It contains the bulk of the raw materials required for industries, and if these raw materials are taken in hand by the Governments of the various parts of the Empire where they exist, and are not allowed to drift into the hands of other Empires without a *quid pro quo* being secured to our own Empire, much will be done to maintain a larger population than we had before the commencement of this war which has been forced upon us by Germany —the country which has always been active in getting possession of our raw materials to support their own industrial population.

In addition to our raw materials, our inventions should also be protected primarily for our own people. The Board of Inventions set up during the war should be continued, and when a great invention is made the inventor should be protected and, if necessary, on the recommendation of the Board, the Government of the country should on fair terms stand behind the inventor, assisting him financially and in the development of the industries his invention may make possible.

I trust that the recently appointed Reconstruction Minister (Dr. Addison) may be successful in his office, and that he will make recommendations which can be accepted by the Imperial Government and the people of this country. Here we have, in connection with the manufacture of munitions, large new towns accommodating hundreds of thousands of munition workers, huge plants, machinery, tools, etc. He must see that, at the end of the war, these are not thrown on the scrap heap; the huts must be preserved for permanent dwellings, the machinery and tools must be used in extending factories for the production of manufactured articles, so that we may, in all parts of the Empire, do without the things that are "made in Germany," which have been for many years finding their way over our borders, in most cases without any obstruction. In the Dominions certainly there has been a preference in customs duties in favour of the Mother Country, but the Mother Country has taken millions of pounds' worth of manufactured goods from Germany, while she has maintained what she calls a balance of trade by supplying her in return with coal, the product of a primary industry, and other raw material imported from various Dominions.

If we can persuade the Government to adopt a sound policy after the war, treating our great Empire as we would our own business, developing

it in such a way that every part of it obtains an advantage by the extension of trade, then we shall have reason to thank the Kaiser for consolidating the Empire and demonstrating to the politicians, or should I say statesmen, that it should be their business to look after their own country first. If it is made impossible for Germans to have any political influence in this country by giving big fat subscriptions to party funds, we shall have much to thank the greed of the Kaiser for. I cannot even now see why he wished to crush England; he was getting practically all his own way in our Empire, particularly in this end of it, using our ships for the purpose of pushing his own trade in our far away Dominions, and filling his war chest out of the profits. Had he waited a few years more he would have had peaceable possession. The war, since it had to come, came, thank God, in time, and when we have won it, it will be our business to see that it is not possible for the Kaiser's successor, if he ever has a successor, to give us so much trouble again.

I have indicated something that must be done to create industries and give employment to the workers. I shall not in this paper touch the question of employer and employees any further than to say I am aware that some keen men on both sides are working to try and get their differences settled, for settled they must be if we are to make peaceful progress.

Now I come to the principal purpose of my paper. It is essential for the future well-being of the Empire; it is the settlement of the parts of our Empire which are not already fully settled. Here we have in Britain and Ireland some 45,000,000 of people, while in Canada, Australia, South Africa and New Zealand we have only about 17,000,000 of white people, practically all of our own race. Now, whilst it may be contended that under existing conditions Britain is carrying her full population, it cannot be thought that it has now its maximum population, if the whole Empire is to grow in such a way as to secure trade for the different parts composing it. No doubt, as the population of the different parts of the Empire becomes more balanced, that is to say, when the Dominions jointly possess the same or nearly the same population as the Mother Country, the Imperial Parliament will have to listen to their protest against the gross injustice of what is known as the double income tax, and will have so to impose its taxation as not to prevent a flow of its surplus capital to the parts of the Empire that take its surplus people. At present, if a British subject acquires wealth in Australia, or any other Dominion having an Income Tax Act, and should come to reside in this country, the British Parliament are not satisfied to tax him on the income he brought to this country, but impose their income tax on all his income in the Dominions; as he naturally had to pay an income tax on the income where it was made, he was called on to pay two income taxes on the one income. It should be clear that one income should only pay one income tax. All that has to be decided is, whether the tax should go to the credit of the country where the income is earned, or to the country where the holder of the income resides. Such questions should be considered and settled on sound business lines, and if the Empire is to be developed as one great united Empire, it appears only fair that the income tax should be imposed only on the income in the country where it is earned.

If people in Britain find that their investments in Australia or New Zealand necessitate their paying two income taxes, or three when the State tax is added, it cannot be denied that the Governments are legislating in favour of investments being made in foreign countries where no income tax is imposed. Everything possible must be done to induce our people to settle our own lands, and much can be done if the various sub-nations composing the Empire —together with the Parliament of the United Kingdom—pass legislation in each other's interests, as though it was a part of a great co-partnership. I mean by not insisting on having its "pound of flesh" when such a policy will make for injustice to one part of the Empire, or indeed the whole of it, simply to ensure a little more revenue for itself.

The settlement of our lands has come to be looked upon as one for immediate attention, owing to the fact that so many millions of men have been engaged in this frightful war, and it is believed that a large proportion of them will, after their experience of the advantage of living a free out-of-door life, decide not to go back to their indoor occupations. Further, they have rubbed shoulders with men from the Dominions who are better paid by their home lands, and they will naturally want to go and settle in one of these wealthy or, at any rate, more liberal lands.

The people of the Mother Country now realise the importance of having great loyal populations in the Dominions to help them fight their battles, though perhaps their

importance before the war as great consuming customers was not so generally recognised. As the Dominions have enormous lands to be settled, all parties are in a mind to take up the question in a manner that will be of the greatest advantage to the individual and the Empire. Of course, there are those who believe the lands of the Mother Country can support a much larger agricultural population than at present find a home here, and efforts are being made by legislation to try to increase the number. This is a very wise policy, and everything possible should be done in the interests of this country to settle people on the land and produce more food for home consumption; but there are reasons why this should not be pushed too far, even if it were possible to settle all the people here to get a "hand to mouth" living. We want to hold the Empire outside of these islands, and it is only possible to hope to do this by obtaining sufficient population in the Dominions to prevent other overcrowded countries putting up a claim for some of them for their own people. I do not mean to say that we want these Dominions settled altogether by our own people, and so debar the people of other countries from settling there; but we wish to have a population practically British in every Dominion, with the knowledge that a generation or two will make our foreign settlers British. We must always remember that our whole Empire must have the British spirit, and that "united we stand, divided we fall."

The Imperial Government appointed a committee, of which I was a member, to consider the measures to be taken for settling within the Empire ex-Service men who may desire to emigrate after the war, and the committee, under the presidency of Lord Tennyson, was composed of representative men most of whom had been connected with the question before the war; they examined a large number of witnesses and made an elaborate report last July to the Right Hon. Walter Long, Secretary of State for the Colonies. In this report the committee dealt shortly with what is proposed to be done to encourage men to settle on the lands of the home country, and expressed the view of the Dominions being favourable to the increase of agriculturists in this country, for it is from this class that they prefer to draw their new settlers—not that there is any hope of all their requirements being drawn from such a class. The Home Government have provided for a minimum wage of 25*s*. a week for agricultural labourers, and a guaranteed minimum price for wheat and oats from 1917 to 1922. If this results in grass lands to anything like the 3,000,000 acres it is hoped will be broken up by the plough, it will lead to a much larger number of both skilled and unskilled farm hands being employed after the war than there were employed in 1913. Legislation has been passed empowering the Board of Agriculture to cut up a few thousand acres on which to establish experimental small-holding colonies. The Board have under consideration a scheme to cut up large areas of land if these experimental farms are a success. If these settlements are a success no doubt the United Kingdom will absorb a number of men, but no matter how many men they may absorb, there are not likely to be anything like the number available fully provided for. We must therefore have a central authority to deal with the whole question, either a Minister or a committee or both. In the report I have referred to, it is suggested that a committee be established consisting of five representatives of the Home Government, one to be nominated by each of the following Departments—

- Colonial Office.
- War Office (temporarily).
- Board of Trade.
- Local Government Board.
- Ministry of Labour.

Four to be nominated by—

- Government of the Dominion of Canada.
- Government of the Commonwealth of Australia.
- Government of the Dominion of New Zealand.
- Government of the Union of South Africa.

One of the Agents-General for the Australian States.

One of the Agents-General for the Canadian Provinces.

Five unofficial members, of whom two should be women.

Where the chairman considered it necessary, the Agent-General for any State specially interested should be invited to a meeting of the central authority, and he should act on the committee as a member thereof. Representatives of other parts of the Empire, such as Newfoundland and Rhodesia, or other Departments of the Home Government, should be similarly consulted, and invited to attend meetings and have like voting powers whenever their interests might be involved. The report makes it clear that the committee were of opinion that the organisations which the

Dominions and States Governments maintain, should have the final voice in the selection of ex-Service men to participate in their own special settlement schemes. They further very properly claim that the central authority should be set up before the conclusion of the war, so as to be ready to deal with ex-Service men. The success of the central authority will depend largely on the Minister under whose Department it is placed; whether it be the Secretary of State for the Colonies, or the President of the Board of Trade, it will be necessary that the Minister himself should take a personal interest in the work. My fear is that, having so many Departments under his control, he will not be able to give the attention which is required to the subject, and it should be considered whether it would not be better to create a Minister of Migration to control the whole business of migration within the Empire.

One of the first problems the central committee will have to face will be the difficulty of transport; over a million of ex-Service men will have to be carried back to their homes in different parts of the world; and if the war lasts long enough to allow America fully to participate in it, then the number may be two or three millions. If a large number of ships are not built and held in readiness, the transportation of this enormous number of men will take years to carry out. Therefore the first thing to be done is to push on with shipbuilding in every part of the Empire, and in every part of the world friendly to our Empire. Having the ships available, or rather the knowledge that they will be available, the central authority can take toll of the men desirous of moving to the outposts of Empire, and can set up machinery in the different Dominions, Provinces, States and Colonies to receive and settle them when they land there. If we in the Dominions convey and settle our men, this Mother Country will have to show gratitude to their own men who have helped to save the Empire. I am of opinion that they will have to be helped financially, and others who may go, making room for some of the soldiers to stay in their old homes, should also be helped in the same way. How can they be helped without casting too great a load on the Mother Country? I think it can be done by giving free transport to any part of the Empire they may wish to settle in, and then using the credit of this country to finance co-operative schemes of settlement and public works, the Dominions taking the supervision of the settlements and control of the money until such time as the settlement money has been repaid. The money expended on public works should be allowed to remain as a part of the Public Debt of the Dominions or States. It is true that this would require a large amount of money to be raised on loan; however, if it means raising as much as the cost of the war for a year—about two thousand million pounds—we shall have a good return for it; it will not go off in smoke and shell, but it will settle and secure strength for the Empire, giving a good asset for every penny expended and building up an Empire so strong in "man-power" that even should Germany make satisfactory progress she will never dare to make war on us again.

Every Dominion, Province and State would be invited to say what it will do—that is to say, how many co-operative bodies of men it could settle within its own borders, providing the money was made available for construction of railways, roads, etc., together with the cash to finance the settlers, the first amount being advanced to the States and Provinces to remain a part of their Public Debt, the second to be advanced to the local Governments for the use of the settlers, to be repaid by them over a term of years.

In the past, settlers have in many British Colonies had to fight with timbered country, which it has taken them practically a lifetime to subdue and fit for the plough; but under a proper co-operative system with capital, an up-to-date plant could be provided to saw up suitable timber, to pull up stumps and shrubs, to erect butter, cheese and bacon factories, these factories to be worked on co-operative lines as is now the general practice in Australia. With other lands, such as the Mallee country, a different plant would have to be provided and larger areas of land secured to each settler.

Again, other areas would require drains, etc., for irrigation, and these blocks according to their location and use would be very much smaller, I mean for the individual settler. Wheat land would, as a rule, require larger areas than what are known as mixed farms, these again being larger than plots of 20 acres or so for fruit-growing. In each of these settlements a piece of land from 200 to 300 acres centrally situated should be reserved for a town which would take form as soon as the land was even partially settled; the general store, the factories before mentioned, the school, blacksmith's shop and bootmaker, etc., would be there. Soon there would follow the branch

bank, chemist, etc. All these would give a value to the land in the town, which if rented and not sold would secure a handsome return for the benefit of the whole of the settlers. Mr. Chomley, of *The British Australasian*, advocated a scheme much on these lines before a Royal Commission in Victoria some years ago, and I have asked him to be present to-day to speak in any discussion that may take place when I have read my paper. Allowing that the most expensive scheme, that is to say, the one dealing with the settlement of a hundred people with families on a hundred farms, might need a capital of £50,000, the men taking the lots would have to work at a rate of pay that would permit them to live in comfort, knowing that the difference between the wage they received and the regular rate of pay would ultimately come back to them in securing the farm at a lower cost, and would be a guarantee of their *bona fides* to the Government advancing the capital. I am not prepared to submit a balance-sheet, but would point out that at the end of three or four years the farms should be sufficiently improved for each man to take over his farm and work it on his own account, the town land and the factories continuing to be owned on a co-operative basis. The clearing machinery could be sold and the amount of purchase money deducted from the debt, and the balance divided by the number of settlers would give the mortgage each farm would have to carry, the owners having the option of paying it off if in a position to do so, or paying over a term of years an annual amount sufficient to pay interest and redeem the whole debt on the property. Of course, conditions would have to be made to permit men who became possessed of sufficient money to buy a cleared or larger estate withdrawing from the scheme on equitable lines, to sell, and in case of death to will to others. Indeed, everything should be so arranged that honest workers should be encouraged to join and remain in such settlement schemes, and provision would have to be made for the expulsion of shirkers.

The Colonial Governments would appoint managers from qualified agriculturists, horticulturists, etc., to work with a committee of the settlers elected annually by the whole settlement. I feel confident that if these suggestions are taken up and acted upon, a workable scheme can be secured.

The money must be found by the Imperial Government, just as it was for land purchase in Ireland; it cannot be lost so far as the Dominion or State Government is concerned; it will really only be a loan of the Mother Country's credit, and so far as the loan to settlers is concerned, they will have the security built up by the lower rate of pay the men receive who are going to buy the land. When the Imperial Government adopt this or some other scheme with as fair a promise of success, they will have done their duty to the men able to go on the land, who have done so much in their time to preserve the British Empire for future generations.

[Owing to Mr. Walter Long having to return to the House of Commons for a short time, the chair was taken, during the reading of the paper, by the Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand.]

DISCUSSION.

The Hon. Sir Thomas Mackenzie thought that the paper dealt in a practical manner with an important and far-reaching subject. The question of the settlement of our people upon the lands of the Empire must engage the attention of statesmen of the Old Country in conjunction with that of the statesmen overseas. The Dominions must be provided with a sufficient population; or other countries might contest the right of the British people to possess such vast territories unused. He agreed with the author that it ought to be largely British settlement. If we had our own people in our own lands we should have a loyal and patriotic people, who would be prepared to stand by us in adversity and to share in our prosperity when it came. He thought the question of the preservation of child life in this country ought to be taken in hand at once, for if the child life that might be saved here was preserved and trained it would furnish as large a population as our overseas communities could properly absorb. It seemed to him that there was great need for the training of the men who purposed going abroad. It was no use sending a lot of ex-soldiers or other men to the overseas Dominions unless they were first trained in the industries that they were likely to take up on the other side. Any scheme for assisting migration from this country overseas ought to be coupled with a system of training to some extent. For many years he had been the Minister in charge of a Land Settlement Department in New Zealand, which borrowed sums of money to re-purchase estates and finance the men afterwards. Vast areas, amounting to over one and a half million acres of land, had been re-purchased from large landowners, and over six thousand new families had been settled on the land; then there followed the stores and chemists' shops and banks and prosperous communities. The Land Settlement Department had borrowed £16,356,000 to help the settlers to clear

their lands and make their settlement a success. That scheme had been so successful that those settlers had repaid £8,256,000, more than half of the total amount that had been borrowed, and thousands of them had made their holdings their own. They were also assisted in erecting factories and shipping their produce across the ocean.

THE HON. SIR JOHN W. TAVERNER, K.C.M.G., agreed with Mr. Long that British people should have the right to make their home within any part of the Empire they chose. The war had consolidated the British people to the extent that those in the Colonies were now allowed to express their opinions on matters affecting the interests of the Empire; and men like Mr. Hughes and other leading public men could tell the Mother Country what her duty was in connection with promoting the best interests of the Empire. He agreed with the author that the Tennyson report was a very good report. The first part of that report was an indictment against the British Government for not doing its duty, and the remaining part informed the people of this country what the overseas Dominions were doing for land settlement. The recommendations of the Tennyson Committee were sound and good, but any policy of migration to the overseas countries should be carried out by the co-operation of the home Government and the overseas Governments, and great care should be taken to see that there was no "dumping" of men on the overseas Dominions. It must be remembered that those Dominions would have their own ex-Service men to deal with, and he thought it would be nearly two years after the conclusion of the war before the overseas countries could get all their men back and deal with the question of their own ex-Service men. After that they would do what they could to co-operate with the Mother Country in dealing with her ex-Service men. In July of 1916 Sir Douglas Haig polled 97,000 men as to their wishes in connection with land settlement, and the result of that poll was that 17,000 men expressed their desire to go upon the land should they return safely after the war. That meant that, taking 5,000,000 men as a basis, 875,000 would have to be provided for upon the land, whereas the British Government had only made arrangements to provide for 300. Thanks to the organised Labour Party in this country, the industrial section of Service men had obtained from the Government a promise that their rights would be preserved after the war, and the Government should give ex-Service men who did not belong to that section an opportunity of making a home on the land in the Mother Country. He would like to give every credit to Mr. Prothero, Sir Richard Winfrey, and Sir Arthur Lee, for the excellent work they had done in that connection. Owing to their efforts, 45,000 ex-Service men were now working upon the land, but nothing had been done by the Government to ensure that those men would be able to make a home in the future within the Mother Country.

THE HON. J. G. JENKINS expressed his great appreciation of the paper, which dealt with a subject in which he had taken the deepest interest for some time. He had been a member of the Committee set up by Earl Grey in connection with the Royal Colonial Institute, and that Committee's work had a good deal to do with the appointment of the Tennyson Committee. It was much more difficult in Great Britain and Ireland to obtain land for settlers than it was in the Dominions, and he believed that the present Government fully recognised that, and that legislation would later on be adopted by which readier access could be obtained to larger tracts of land for the settlement of men who desired to work upon the land. The question of colonisation must be considered from a national citizenship point of view. The time had gone by when people in New Zealand and Canada and Newfoundland were considered foreigners; they had just as much right to be considered members of the British Empire as those who were born and lived in the Mother Country. With reference to Sir Thomas Mackenzie's remark that if the right kind of people were settled on the land, nothing would be lost by re-purchasing and selling land to those people, the Government of South Australia had spent millions of money in re-purchasing and settling men on the land, and had never lost a penny by those schemes. He would also like to emphasise the statement made by Sir Thomas Mackenzie that it was generally useless to put people on the land if they had no knowledge of the work they would have to do. Sometimes men who had never worked on the land before managed quite well, but the majority of them needed a certain amount of instruction in agriculture in the country in which they intended to settle. Such instruction was given at agricultural colleges in Australia, Canada, New Zealand and South Africa, and he thought such colleges might also be established in the Mother Country. He hoped that the Government would appoint a permanent committee on the lines suggested by the Tennyson Committee, in order to arrive at a basis of agreement between the Dominions and the home Government as soon as possible, so that after the war the problem of settling ex-Service men on the land could be properly dealt with. It did not matter if millions had to be borrowed for that purpose, because the undeveloped resources of the Empire would return an adequate interest on any amount of money that was expended in that direction. There were millions of acres in the overseas Dominions waiting to be cultivated, and if a uniform scheme of migration was arranged between the home Government and the Governments of the Dominions, it would result in permanent benefit to the British Empire.

COMMISSIONER D. C. LAMB, Salvation Army, said that the author had mentioned what he called an expensive scheme of settling one hundred people with families on a hundred farms at a capital expenditure of £50,000,

i.e. £500 per family. When he took what the British Government had done he found it worked out at £900 per family; but no man would have a better chance in the north of Scotland, say, than in Western Canada. He felt rather doubtful as to how far settlement in the home country should be proceeded with. The author had spoken in his paper of the increased acreage that was going to be brought under the plough; of guaranteed wages and of a guaranteed price for wheat and oats; but he was not sure that there would be more people on the land even then. With improved machinery so many people would not be required. What was really wanted was more production. With regard to the need for training men for work on the land, that would not be so necessary in the future as it had been in the past, because the ex-Service men would be found to be capable of adapting themselves quickly to new conditions. Statistics published last week showed that in a certain part of the British Empire the percentage of British and British-born citizens was only 60 per cent. of the population. That must be altered in the future, but, as had been already said, there must be no "dumping" of men on the Colonies. The Salvation Army long ago saw the evils of such "dumping," and organised emigration in such a way as to prevent that evil. They selected people from amongst those who wanted to emigrate, tested them in certain ways, secured their passages and arranged for them to be met on their arrival, and did everything possible to prevent the men from feeling that they were being exiled. They went straight from the ship to the work that had been found for them, and the Salvation Army insured them against accident, loss of luggage and unemployment. If the Salvation Army could do all that, surely the State, if it took the work in hand, could multiply it, and in that way there could be no possibility of failure.

Mr. C. H. Chomley said he had had some practical experience as a settler on the land in Australia, and had himself ploughed many acres of bush land. He was quite sure that in Australia or any other Colony there was hardly a single man who, under proper direction, even without experience, was not perfectly capable of earning his keep and a moderate wage from the very beginning. Men under direction and discipline and receiving wages, as a rule, could be made to do good work; and, on the other hand, men who had the incentive of owning their own property would also do good work. In his scheme, which the author had mentioned, he had attempted to combine those two things. Roughly, his scheme was that a Government—or preferably, from his point of view, an association of private individuals—should take over a certain large area of, say, 10,000 acres of bush land in the Dominions, which had all the elements of fertility, but which, under individual settlement, could not be properly developed, because it was far from a railway and its amount of timber was greater than individual settlers could cope with. He proposed that the Government or association should equip that area of land with sufficient capital to provide saw-milling plant, which would convert the timber from being an incubus to the individual into a great asset to the community. The timber would be cut into lengths, stored and seasoned, and after three or four years it would be sent to a railway, and in many cases that timber would more than pay the whole of the cost of clearing the land. When cleared, those 10,000 acres would be divided up into lots of 100 acres, so that 100 men would be settled on them. He suggested that the company, or the people who provided the capital, should pay those men a living wage for a term of three years, say £1 a week, and establish stores at which they could buy everything they required at the lowest possible cost; clear the land, divide it, put fences on it and build houses, and, at the end of the three years the land should be given to the men in the form of 100 farms. They should be debited with the money spent upon the plant and upon their wages, less the cost of the timber which had been sold and the sale of the plant which had been used for clearing the land. In many cases, instead of there being a debit to the community, there would be found to be a credit at the end. Even assuming that there was no credit side to it at all, there would be a hundred families in a settled community entering upon cleared farms in three years, having been taught to manage the land themselves. He suggested that when those 10,000 acres of bush land were taken up in some central position, there should be reserved an amount adequate for a township, say, 300 acres, and that those 300 acres should be the property of the community, a half-share going to the people who had provided the capital, and a half-share going to the settlers who formed the community. A hundred good farms would form the nucleus of a very flourishing settlement, and in time to come those township lands would be very valuable, and their sale, or the rents from them, would go a long way towards recouping the capitalists for the money they had expended. He was convinced that if the proper land was selected his scheme might be repeated over and over again in Australia, New Zealand, Canada, and even the Mother Country, the people who supplied the capital obtaining an interest of about 5 per cent. as well as a half-share in the value of the town lands.

Mr. H. E. Easton (Hon. Secretary, British Empire Land Settlement Propaganda League) thought that thanks were due to the Government and to Mr. Long for the able work they had already done. Sir Richard Winfrey had made a proposal to the Government to take over one and a half million acres of land for cultivation by ex-Service men. He hoped those proposals would

meet with the necessary support, and that the Government would not hesitate to give Sir Richard Winfrey and his Department (the Board of Agriculture) the legislative power they wanted. The British Immigration League had received many letters from officers and men at the Front saying, "Is the only reward for our fighting to be told by the British Government that we have got to migrate from the very land that we have fought for?" It would not do to weaken the heart of the Empire too much, but if the overseas Dominions were not going to be replenished with British settlers, they might have to look to the nations we were to-day at war with for their future supply of population. Mr. Lloyd George, in answering a deputation in March last, said, referring to settlement on the land after the war, that not a day ought to be lost, because, if it was, the opportunity would pass away. A good many days had already been lost, and, in spite of the Prime Minister's warning, all that the Government had done was to make arrangements for the settlement on the land of less than three hundred men.

Mr. Henry Samuel said he happened to be the representative for the overseas Dominions at the Small Holdings Congress which was held at the Crystal Palace under the Presidency of Lord Carrington (now Marquess of Lincolnshire), and he hoped the Government would not attempt to develop land in this country under a small holdings scheme. No ex-soldier would ever be able to exist under that system. The large amount of capital required to settle the men on the land should be provided by private enterprise, probably under some such scheme as that which Lord Cromer introduced to develop Egypt, namely, by the Government guaranteeing a minimum dividend.

Mr. Octavius C. Beale then proposed a vote of thanks to Sir John McCall for his paper.

Major-General the Hon. Sir Newton J. Moore, K.C.M.G. (late Agent-General for Western Australia), in seconding the resolution, said that some of the suggestions put forward in the paper had already been carried out in Australia. He hoped the new committee would be very careful to appoint practical men who could dissect the various proposals that were made. The land first had to be classified—the land in Australia, for instance, being very "patchy," and a chessboard scheme not being practical politics there. The question of transport facilities also had to be considered.

The resolution was carried unanimously.

On behalf of the Council, Lord Blyth, Chairman of the Colonial Section Committee, thanked Mr. Long for his kindness in taking the chair at considerable personal inconvenience.

The Chairman (Mr. Walter Long), in reply, appealed to those who criticised the Government for not doing more in the way of settling men upon the land to bear in mind that at the present time the only men who were released from military service were men suffering from repeated wounds or serious deterioration of health, and those were not the men who could begin a great scheme of the kind in question. It was not right to blame the Government because only a limited number of men had been settled on the land. He was in general agreement with the paper, and also with the remarks of some of the speakers, especially Commissioner Lamb. In connection with the settlement of men on the land, the motto *festina lente* should be remembered, as there was no question about which it was so easy to make mistakes and so difficult to redress them. Wisely and well thought out it might bring benefit both to the Empire and to the men themselves, but hurriedly undertaken it might bring great trouble upon the Empire and greater disaster upon the men. Any seeming delay on the part of the Government was due neither to want of will nor to want of energy, but solely to the desire to proceed with due caution, and to consider carefully the steps to be taken before they were beyond the power of being retraced.

The meeting then terminated.

Sir John McCall, in reply to the discussion, writes:—In returning thanks for the vote, I should like to say that my object in reading the paper was to get a scheme discussed, and to render help to the Government in the enormous task before them. Further, I wish to make it clear that the Dominions and States are doing their full part in looking after their own men, and that they cannot be expected to provide for the soldiers belonging to the Mother Country as well. I had no desire to criticise the Imperial Government, and am sorry the discussion in part took that turn: as a matter of fact, I do not know what they have done beyond obtaining the Tennyson Committee's report. I am anxious to impress upon the Government the importance of providing passenger ships, without which no scheme will be possible, and, secondly, that they must finance any scheme for their own men if it is to have a chance of success.

ENGINEERING NOTES.

The Quebec Bridge and the Catskill Aqueduct.—The technical press has given ample details of two recent engineering undertakings. The first is the account of the practical completion of the Quebec Bridge which took place on September 20th last, after the failure of the bridge in 1907 owing to faulty design, and a partial mishap of last year, due to what may be properly termed accident. We owe the design

and erection of this greatest of bridges to the ability and courage of many brains, and it is well to remember that the profession has triumphed over its many difficulties and disappointments. The other enterprise, the Catskill Aqueduct, finished in the middle of October, will be hardly less important. After twelve years' co-operation with the other water supplies which have been in operation for years, 500,000,000 more gallons of water per day can be brought to New York to-day. The work cost £22,000,000. The New York Board of Water Supply was organised in 1905, and at once selected Mr. J. Waldo Smith as their engineer-in-chief. The works extend from the Schohate and the Esopos gathering ground, 600 square miles in all, and lead to the Hudson River, which is crossed by a subaqueous tunnel. These two undertakings, were they not greatly overshadowed by the war cloud, would be classed as engineering works of the first magnitude.

The Dikes of Ostfriesland.—The proposal, initiated by the *Graphic*, to flood the country containing the ports of Emden and Wilhelmshaven by breaking down with bombs the earthen embankments which shut out the sea, is a novel instance of aerial strategy. We presume that the drowning of the civil inhabitants of the country, which the proposal involves, is not intended. The fens (forty-two miles east to west) are protected by dikes 20 ft. to 30 ft. in height, and to show the injuries done to the fens in the past, instances are given of the inundations of 1218, 1511, 1717, and 1825, in which many of the inhabitants were drowned. Bomb attacks by aeroplanes are mentioned as a means of carrying out this proposal.

Brisbane Water-supply Reservoir.—A concrete dam of gravity section with rock plums, faced with reinforced steel rods, 125 ft. high from foundation to top, designed to impound about 7,000,000,000 U.S. gallons of water, was officially put in use in December 1916 by the Metropolitan Water Board of Brisbane, Queensland, Australia. The structure, according to the *Engineering News Record* of New York, is known as the Cabbage Tree Reservoir dam, and is a part of the waterworks system of Brisbane and its suburbs, supplying a population of about 158,000 at the close of 1916. The main supply is taken from the Brisbane River, by means of a pumping-station about twenty miles from the city. The new dam is located on Cabbage Tree Creek, a tributary of the Brisbane River. The dam is five and a half miles from the pumping-station, with which it will be connected by a concrete conduit. The reservoir has an area of about 700 acres and a catchment area of twenty-eight square miles. The dam rests on blue quartzite, which was found at a depth of 15 ft. below the creek bed. The dam proper is 580 ft. long, and beyond it is a spillway 160 ft. in length. The main construction quantities were: Excavation, 33,222 cubic yards; extra excavation, below assumed bottom, 5,859 cubic yards; spillway excavation, 64,500 cubic yards; cyclopean concrete, 58,400 cubic yards. The rainfall in and near Brisbane is intermittent. For long periods no rain falls, but periodically there are downpours. The longest known period of drought was in 1915, when for eight weeks the Brisbane River was dry. When full, and after allowing for evaporation, the new reservoir will give a supply of 15,000,000 U.S. gallons a day for 300 days, or with greater economy for a longer period.

Continuous Current by Turbine.—The practice of generating continuous current by the use of turbo-alternators, feeding into rotary converters, is rapidly extending. The *Daily Telegraph* says that in a typical plant of this character, which has recently been installed in an important engineering works, there is to be noted a 1,500 k.w. "Witton" turbo-alternator, running at a speed of 3,000 revolutions per minute, and generating six-phase alternating current, which is delivered to two 750 k.w. "Witton" rotary converters, running at 600 revolutions per minute, and generating continuous current at 460 volts. The installation has proved completely satisfactory, and has again demonstrated the utility of this method of generating continuous current, which enables the turbine to be run at a high speed of 3,000 revolutions per minute, so that the highest efficiency is attained, while at the same time the continuous current commutators on the converters can be designed with a peripheral speed consistent with satisfactory working. Providing an interesting contrast to the above-mentioned plant, there is also to be seen in the same works a 750 k.w. "Witton" continuous current turbo-generator set, which has now been running for over ten years. This type of machine is now superseded for the generation of continuous current by the combination described. Other authorities favour the method of driving the continuous current generator through reduction gearing.

Italian State Railway Electrification.—M. Lucien Pahin contributes an article in *L'Industrie Électrique* on the electrification of the Italian State Railway from Bussoleno to Modana. This railway comprises two sections. One extends from Bussoleno to Bardonecchia, about twenty-five miles. Here there are declivities averaging 1 in 20, and many tunnels and artificial structures where steam operation creates intolerable conditions. The other section extends from Bardonecchia to Modana, on Mont Cenis. It is

11·8 miles in length, and includes the Col de Frejus tunnel 45,000 ft. long, which is ventilated artificially. The growth of traffic had caused many difficulties in the operation of this railway by steam, all of which have been overcome by the adoption of electricity with the increased capacity, regularity and speed thereby obtained. Power is to be supplied eventually by hydro-electric installations in the valleys of the Alps, contracts having meanwhile been entered into with the municipality of Turin for three-phase energy at 55,000 volts 50 cycles, produced by a 3,500 kva. turbo-alternator—this to be supplied by energy from other sources.

Coal in Queensland.—The engineers of the Queensland Mines Department report that they have proved over an area of one square mile of the Bowen coalfield, deposits representing 22,000,000 tons of coal. It is certain, therefore, that we may look for important developments in this region in the near future. Electrolytic works at Bowen, mines and smelting works at Cloncurry, may become large users of power, while Bowen and Townsville are the nearest Australian ports to the Panama Canal. Ships sailing from more southern ports of Australia for the Panama Canal must coal at one or other of these points. Crown lands of about 500,000 acres in extent, are available for settlement at Bowen.

Removing Rust by Electrolysis.—An electrolytic process of deoxidisation, says the *Scientific American*, has been patented in the United States. The object to be treated is made the cathode in an electrolyte containing phosphoric acid. In addition to its normal function of carrying the current, this acid acts as a solvent upon rust without attacking the steal or iron body beneath. It is in this last detail that its chief availability lies, since nitric, sulphuric, or hydrochloric acid would not display such moderation. Finally, the phosphoric acid is beneficial in preventing subsequent further rusting. The electrolyte is made by adding ten parts of phosphoric acid to ninety parts of water, or adding 10 per cent. of the acid to a 10 per cent. solution of sodium phosphate. A temperature of between 50° and 70° C. is recommended.

OBITUARY.

WILLIAM CHARLES KNIGHT CLOWES. — Mr. William Charles Knight Clowes died on Monday, the 19th inst., at his house in Cranley Gardens, South Kensington. He was born in July, 1838, and was therefore in his eightieth year at the time of his death. He was the eldest son of George Clowes, the son of the founder of the well-known printing firm of William Clowes & Sons. Mr. Clowes was educated at Eton and Christchurch, Oxford, and after leaving the University he joined his father's firm. In the early days of the Volunteer movement he raised a company among the employees of the firm, and of this he became the Captain. On his father's death the principal management of the printing business, in which he had previously taken an active part, came into his hands; and, later on, when the firm was made into a limited company, he became its Chairman. The Beccles printing business, founded separately by him, together with his cousin, at an earlier date, was at the same time amalgamated with the London house.

At an early date in the history of their business Messrs. Clowes acquired a high reputation for fine and beautiful printing. Their productions were many and various, and it may be said that all the more important of their undertakings were brought out under the direct personal superintendence, first of the grandfather, then of the father, and afterwards of the son. George Clowes took a prominent part in the production of the catalogues and other publications of the 1851 Exhibition. The Jury Reports of the 1862 Exhibition (issued by the Society of Arts) were printed by Messrs. Clowes, to whom were also entrusted the printing of all (or nearly all) the publications issued in connection with all the succeeding great International Exhibitions, down to that of Chicago in 1893. The "Law Reports" were established by the joint efforts of father and son, the firm guaranteeing the necessary funds. The firm made a speciality of printing in foreign languages, and by the purchase of the large stock of foreign type accumulated by Messrs. Gilbert & Rivington, they were enabled to extend this branch of their business, and they would now undertake to set up and print manuscripts in any language which possessed an alphabet. The reputation of his firm naturally led to Mr. W. C. Knight Clowes taking a very prominent part in all matters connected with the printing trade, a part for which his personal character and capacity amply qualified him. He was the founder of the London Master Printers' Association, and the valuable work he did as Chairman of that Association was recognised by his colleagues, who presented him with a service of silver plate on his retirement. Latterly, failing health and advancing years compelled him to take a less active share in the management of his firm's business, and he resigned the Chairmanship in 1915.

He was elected a Member of the Society in 1885, following the example of his father, who had been a Member from 1851 till his death in 1886. He was twice elected on the Council, in 1905 and 1909. He was a very old member of the Athenæum and the Oxford and Cambridge Clubs, having nearly completed fifty years' membership of the former when he resigned last year. He was well known to a large circle of friends, who appreciated his high character and his kindly, genial nature, and who in years gone by frequently enjoyed his generous and cordial hospitality.

WILSON NOBLE.—Mr. Wilson Noble, who had been a member of the Royal Society of Arts since 1888, died on October 31st. Born in 1854, he was educated at Eton and Trinity College, Cambridge, of which he was a Fellow. From 1886 to 1895 he sat as Conservative M.P. for Hastings. He devoted a great deal of time to electrical investigations, especially in connection with X-rays, and did some excellent work in the early days of the medical applications of radiography. He was President of the Röntgen Society of London in 1899-1900, and wrote some important papers on X-ray technique.

ALEXANDER MACOMB CHANCE.—Mr. Alexander M. Chance died at Torquay on the 22nd inst., at the age of seventy-three. He was for many years associated with the management of Messrs. Chance Brothers & Co., chemical manufacturers, of Oldbury. Generous and public-spirited, he spent large sums on schemes for the benefit of his workpeople and on charitable works. He succeeded the late Mr. Arthur Chamberlain as Chairman of the Birmingham Licensing Committee.

He was elected a member of the Royal Society of Arts in 1882, and in the same year he read a paper on "The Recovery of Sulphur from Alkali Waste (Schaffner and Helbig's Process): a Record of Recent Results," for which he received the Society's silver medal.

GENERAL NOTES.

SUBSTITUTE FOR BRAN. — *Il Sole* (Milan) for September 14th publishes a notice regarding a new industry in Liguria, which has arisen out of the discovery of a substitute for bran. The substitute, it is said, is manufactured from materials which, before the war, were practically wasted. The main constituent of the substitute is sugar obtained from the fruit of a species of palm which abounds on the Ligurian coast, and which has hitherto been considered useless. By a special process this fruit has been made to yield as much as 40 per cent. of sugar, which is added to dried figs, rice husks, dregs of pressed grapes, raisin stones, acorn husks, young twigs and tomato parings, after the whole has been subjected to disintegration, pulverisation and kneading. *Il Sole* gives an analysis of the bran substitute thus produced, and points out that the high percentage of sugar which it contains renders it a suitable food for horses. A factory is stated to have been established at Loano capable of producing 200 metric quintals (nearly 20 tons) of the bran substitute per day.

INDUSTRIAL FATIGUE. — In the course of a Chadwick Lecture on "Fatigue and the Worker —Causes, Effects, and Reliefs," Professor Henry J. Spooner said that the success of women in operations hitherto regarded as men's tasks had been remarkable, and a distinguished engineer had declared his conviction that, given two more years of war, he could build a battleship, from keel to aerial, entirely by woman labour. The nation's call upon the industrial army to work the longest hours possible had been nobly and patriotically responded to, but observation and experience had shown that when the working hours were too long, fatigue toxins developed and weariness reduced exhilaration of effort, increased nerve-strain, and induced breakdown. The gross output was increased when long hours were reduced, so the problem to be solved was what length of working-day was, on the whole, most economical and best for the worker. The lecturer's investigations had tended to prove that the abolition of Sunday work and the shortening of working hours, with more general adoption of short intervals of rest, varying in length and frequency with the work done, would still further increase output, the other conditions remaining the same, but there were obvious difficulties in arranging this in practice. Holiday fatigue first led to a falling-off in production, but the recuperative effects of a holiday were soon operative, with consequent increase in production. Methods of preventing waste of time and effort in work were described, which in cloth-folding had reduced motions of the worker from 20 and 30 to 10 and 12, and had enabled a typist at a contest in New York to defeat the international champion by writing the unheard-of gross of 147 words per minute for the entire contest, and 137 words net, or five words per minute more than anything that had previously been done. The economy of movement gained by assembling small machines on the Gilbreth principle, with specially-arranged packets of the component parts, was also shown.

ELECTRIC TRUCK FOR WHARF WORK AT WELLINGTON HARBOUR.—H.M. Trade Commissioner in New Zealand has forwarded particulars of a series of tests carried out at Wellington with a new electric storage battery truck, intended for use on the waterfront. The truck is of American manufacture, and is the first of its kind seen in New Zealand. It is about 8 ft. long and 3 ft. wide, and runs on four small wheels placed underneath the body. The batteries, of which there are forty-two of the Edison type, are carried under the platform, and thus do not take up any carrying space. The batteries are capable of running the truck for a full working day. The driver stands on two divided steps at the end of the vehicle. One of these steps switches the current on when it is desired to start the truck, and the other controls the brake. The steering, which is done on all four wheels, is effected by a tiller, and the electric motor is controlled by a small lever placed at one side of the platform. The capacity of the truck itself is 4,000 lb., and the price is about £500.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

December 5.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "Discovery and Invention" (Inaugural "Trueman Wood" Lecture). Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside.

December 12.—Lord Charnwood, "Technical Training for Disabled Soldiers and Sailors."

December 19.—Professor J. Wemyss Anderson, M.Inst.C.E., M.I.Mech.E., Dean of the Faculty of Engineering and Lecturer in Refrigeration, University of Liverpool, "Science and the Cold Storage Industry." The Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand, will preside.

Indian Section.

Thursday afternoon, at 4.30 p.m.:—

December 13.—D. T. Chadwick, I.C.S., "The Trade of India with Russia, France, and Italy." The Right Hon. Lord Islington, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

Cantor Lectures.

Monday afternoons, at 4.30 p.m.:—

H. C. H. Carpenter, M.A., Ph.D., M.Inst. M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology. "Progress in the Metallurgy of Copper." Three Lectures.

December 3, 10, 17.

The arrangements for the meetings after Christmas were announced last week.

MEETINGS FOR THE ENSUING WEEK.

Monday, December 3...ROYAL SOCIETY OF ARTS, John street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor H. C. H. Carpenter, "Progress in the Metallurgy of Copper." (Lecture I.)

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Mr. W. Dale, "Prehistoric Man: his Antiquity and Characteristics."

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 6 p.m. Annual General Meeting.

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Tuesday, December 4...Swiney Lecture, at the Royal Society of Arts, John-street, Adelphi, W.C., 5.30 p.m. Professor J. S. Flett, "The Mineral Resources of the British Empire." (Lecture X.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Mr. G. B. Walker, "Recent Developments in By-product Coking."

University of London, University College, Gower-street, W.C., 5 p.m. Professor S. D. Adshead, "Housing Problems after the War." (Lecture V.)

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Miss A. M. Anderson, "Women Workers and the Health of the Nation."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. Professor H. Louis, "The Economics of Coal Production."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C. Mr. A. K. Sabin, "Ecclesiastical Wall Paintings in England from the XIIIth to the XVIth Centuries."

London Chamber of Commerce, Oxford-court, Cannon-street, E.C., 2.30 p.m. Lord D'Abernon, "Improved Sea Communication."

Wednesday, December 5...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Sir Dugald Clerk, "Discovery and Invention." (Inaugural "Trueman Wood" Lecture.)

Aëronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m.

Geological Society, Burlington House, W., 5.30 p.m.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 5 p.m. 1. Messrs. P. J. Fryer and F. E. Weston, "The Valenta Number as a discriminative Test for Oils and Fats." 2. Mr. H. E. Cox, "The Composition of Sharps and Bran." 3. Mr. W. T. Burgess, "Notes on Porcelain." 4. Mr. E. R. Dovey, "Note on the Colorimetric Estimation of Iron."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. A. H. Thompson, "Some Notes on the Lesser Colleges of Secular Canons in England."

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Messrs. E. Heron-Allen and J. E. Barnard, "Demonstration on the Application of X-Rays to the Determination of the Internal Structure of Microscopic Fossils, especially with regard to the Dimorphism of the Nummulites."

Thursday, December 6...Swiney Lecture, at the Royal Society of Arts, John-street, Adelphi, W.C., 5.30 p.m. Professor J. S. Flett, "The Mineral Resources of the British Empire." (Lecture XI.)

Chemical Society, Burlington House, W., 8 p.m. Dr. F. L. Pyman, "The Relation between Chemical Constitution and Physiological Action."

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Captain H. R. Hall "The Excavation of an Egyptian Temple (the Temple of Menhihotepat Deir-el-Behari)."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. W. A. Gillott, "Electrical Cooking as applied to large Kitchens."

British Academy, in the Theatre, Burlington-gardens, W., 5.30 p.m. Major Sir Filippo de Filippi, "Italy's Protection of Art Treasures and Monuments during the War."

Friday, December 7...Swiney Lecture, at the Royal Society of Arts, John-street, Adelphi, W.C., 5.30 p.m. Professor J. S. Flett, "The Mineral Resources of the British Empire." (Lecture XII.)

Philological Society, University College, W.C., 8 p.m. Professor W. Rippmann, "Simplified Spelling."

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers nearly four thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, DECEMBER 7, 1917.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 10th, at 4.30 p.m. (Cantor Lecture.) H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, "Progress in the Metallurgy of Copper." (Lecture II.)

WEDNESDAY, DECEMBER 12th, at 4.30 p.m. (Ordinary Meeting.) LORD CHARNWOOD. "Technical Training for Disabled Soldiers and Sailors." SURGEON-GENERAL SIR ALFRED KEOGH, G.C.B., M.D., F.R.C.P., Director-General of Medical Services, will preside.

THURSDAY, DECEMBER 13th, at 4.30 p.m. (Indian Section.) D. T. CHADWICK, I.C.S., "The Trade of India with Russia, France, and Italy." The RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On Monday afternoon, December 3rd, Mr. H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, delivered the first lecture of his course on "Progress in the Metallurgy of Copper."

The lectures will be published in the *Journal* during the Christmas recess.

JUVENILE LECTURES.

A course of two lectures, adapted to a juvenile audience, will be delivered on Wednesday afternoons, January 2nd and 9th, 1918, at 3 p.m., by Mr. P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, on "Animal Camouflage."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 28th, 1917; THE HON. SIR CHARLES ALGERNON PARSONS, K.C.B., LL.D., D.Sc., F.R.S., Vice-President of the Society, in the chair.

THE CHAIRMAN, in opening the meeting, said it might be interesting to recall the position of aeronautics in the year 1887, thirty years ago, when he was personally very much interested in the subject. He read the works of Langley, the American experimenter, and the works of most other experimenters at that date, and he studied models of aeroplanes and helicopters, himself making a helicopter which lifted itself 20 or 30 ft. from the ground by its own power, by means of a steam engine. When the same helicopter was mounted on planes, like the modern aeroplane, it flew for several hundred yards. About two or three years before that, Langley had made a small flying machine of about 10 lb. weight, which had flown about half a mile over a lake. Langley further carried out very elaborate experiments on what were now called "lift and drift" measurements, that was to say, if the planes were properly set, a certain amount of lift was obtained by pressure upon the air. Upon that factor of propelling force at given velocities, and the amount of lift obtainable, rested the whole possibility of flight. He (the Chairman) came to the conclusion at that period that, with a full-sized steam engine, an aeroplane was perfectly possible. That was long

before Maxim attempted to realise the result on a full-sized scale. At that time his summary of the position was that with steam-power flying could be realised, but that it would be impossible to carry the necessary amount of water as an air-condenser, because of its weight, and that flight could therefore be maintained for only about half an hour. The light petrol engine had not then been evolved. At that time he was induced to go in for steam turbines, which was a very arduous pursuit and necessitated his abandoning the study of flying-machine questions. Ten years ago came the Wright brothers and other experimenters, many of whom lost their lives in developing the glider. That was the great obstacle in the way of the development of flying machines—the danger of the experimenters losing their lives. The author of the paper about to be read, Colonel O'Gorman, would deal with the present state of aeronautics. Beyond being a member of a few air committees, he personally had had practically nothing to do with aeronautics for the last thirty years.

The paper read was—

COMMERCIAL AERONAUTICS.

By Lieut.-Col. Mervyn O'Gorman, C.B., D.Sc.

Aerial Transport and Travel.

There is talk to-day of aircraft for transport and travel. The carriage of goods, mails, and people, the exploration of remote districts, the conduct of photographic surveys, the searching out of valuable trees in pathless forests, the speedy conveyance of officials to their administrations in distant climes—these things and others are everywhere hopefully dwelt on by the imaginative among those engaged in air work. It would be grossly unjust to say that such hopes and fancies detract from the energies which these persons expend on their war duties; they rather indicate the intention of winning and of carrying on thereafter the life of a virile community.

The public at large, like Gallio, cares for none of these things, and is a trifle jealous of any thinking which is directed to reconstruction. This attitude, though explained, is not fully warranted by war preoccupations. Once a month, when a bomb or so is aerially transported from Germany to London, we say: "Let us have a new Air Board, Air Council, or Air Ministry," but this can scarcely be described as original or effective thinking. A democracy has got to think, since it has chosen to govern; and when it realises that the mechanism which so easily brings those bombs, in spite of opposition, might very usefully carry a more amiable freight, it will be joining those who see a place for aircraft in our reconstruction. In a paper before the Aëronautical Society, in June this year, I gave reasons to show that in the interest of the war we must care about the future of transport by aircraft. I will recapitulate the position under *A*, *B*, and *C*, for there are three stages in the logic of the matter:—

A. We are to have an Air Ministry and an Air Force; the Act shows that they are not temporary—a token from which alone we may say that we intend to have a fighting Air Fleet.

B. An air fleet differs from a sea fleet in being much more easily expendible. No one would dream of rebuilding the British High Seas Fleet six or eight times per year of war, but an air fleet in action requires, and will continue to require, at least this. Thus the aeroplane has in this context the interesting singularity of being intermediate between a cartridge and a battleship. It is not quite so rapidly expendible as the former, but it is an expendible munition, and when we decide to have an air fleet we also decide, in logic, on the third conclusion, *C*.

C. This corollary is that we will maintain an aircraft construction organisation in peace that shall be competent to produce some six or eight air fleets per annum in war.

At present we have such an industry—not large enough perhaps, but we have at least a live and flourishing plant which is bearing fruit, which can grow, and which, be it noted, can also expire. A living organism can be killed by deprivation of oxygen. In three minutes a man is drowned, and forty years' training of brain and hand can be thus quickly reduced to an inert mass. Similarly rapid is the rate of disintegration of a highly organised technical production department like the aircraft industry, if it be starved. To-day war orders continue at full flood to fill up the wastage. If they stop suddenly we shall find within three months that the shop organisations are broken up, that all that remains to us is the husk; we shall realise that we could, by timely measures, have saved much of our expensively purchased experience and organisation, and have retained a value far greater than the mere buildings and plant. Once the designers and workmen are scattered, that which is so difficult and expensive to build up will be gone. Our capacity for the production of aircraft will be an object of derision like a bouquet of hairs in an old broom.

This simile will have succeeded if it has led a few score of persons to inquire, "What on earth are we to do to keep this mechanism of production in being without keeping up in peace the

war rate of expenditure?" A part of the answer was outlined in my first sentence; we must so utilise aircraft on commercial duty, and so nurse it in its days of trouble, that it shall itself earn the best part of its keep.

If aircraft using can be induced to pay, aircraft-making will of itself continue. But, in spite of the firmest belief in the value of aerial travel, the mere institution of services takes time. Neither three months, nor six months, nor a year, will see a thriving mercantile air fleet engaged on its routine duties, and issuing its routine orders on which the construction business depends. Yet a less period of inaction than this will extinguish the industry. This is the period I ventured to call the "hiatus" in the discussion on Mr. Holt Thomas's historic lecture last May. To bridge the hiatus we must do something *now*. There is no other alternative. No one expects a continued unrequited expenditure of from twenty-five to fifty million pounds per annum on aerial war material in peace time. On the other hand, no one would object to our making even this large amount of aircraft if it nearly earned its keep by remunerative services in any of the travel and transport businesses, or even if we could be assured that, after a period of Government support, it would eventually draw near to the standing of a self-supporting industry.

If we look back to the birth of the railway and the steamboat we see that for some years they struggled against public apathy—though their potentiality for good and for the creation of wealth and trade was almost as great in Watt's time as now. This apathy, amounting to boycott, rendered them unremunerative for a long period, and deprived the world of travel, and joy and change, and fresh air, and trade progress for well-nigh a generation. In the case of the road vehicle which we now call a motor-car, we had something worse than apathy—we had legislation for the alleged protection of the public, all meant in kindness—which killed the motor-car of 1837 and retarded the car of 1892, till France was well ahead of us. In the case of dynamo electricity we underwent a process of protective legislation against shock and fire possibilities, which threw us well behind Germany and the United States. The story of legal impediments to scientific advance makes one wonder whether we are a free people—that is, with freedom to advance, or are we only set on freedom to stagnate?

The greatest danger that aircraft has to fear, after public apathy, is legislative interference. It is not that the British law, excepting only when it is panicky, is worse made or more malignantly administered than another. The kindly intentions of legislation towards the public are generally as laudable as our laws in technical matters are detrimental. Yet such a community as ours can only live and thrive on its technicians. We are prone to drown the puppy lest he should bite, instead of adopting our own unique maxim of allowing the law to lag so that the puppy shall have one fair bite before he is muzzled.

We now know that it was shameful to have waited for the war before building up our Department of Scientific and Industrial Research. No branch of administrative expenditure was known to pre-war politics whose function was to venture forth, or to encourage us by press publicity, or otherwise, to advise the public to risk a little inconvenience during the period of evolution of a difficult art or science. The four-mile, the twelve-mile, and even the twenty-mile per hour motor-car speed limit prove that technical legislation has hampered and did not encourage. Of legislation relating to aerial transport it may safely be said that it is a case requiring the greatest delicacy of handling. It must be taken as certain that Government assistance, I do *not* say subsidies, for the industry must be forthcoming unless it is doomed; but even if this assistance were certain there remains cause for anxious thought to-day.

The danger of Government support lies in the conditions which a self-protective public is liable to impose before the technical possibilities are sufficiently known to form the basis for any sort of legislative interference. These conditions are liable to be all the more onerous since they could be imposed as of right, and regarded as a *quid pro quo* for the "*assistance*." The fearful might say that a great unknown risk to those on the ground (*omne ignotum pro magnifico*) is involved in any programme of commercial aeronautics. The braggart has already talked of a sky darkened by aeroplanes, of the cerulean clotted with colliding aircraft, and the timid voter silently wonders how *he* is to be protected from the *débris*. Luckily we have the facts with which to dispel this apprehension. To-day we may safely say that millions of pounds' worth of aircraft is yearly poured out from this country's factories. The large majority of this is flown to its destination, or used for tuition and defence at home, yet we still see the sun.

We have a full measure of the nuisance exag-

gerated by the more hurried training of flyers, and the extreme lightening of structure imposed by war conditions. Such nuisance as there is is purely local, and is really negligible. Now there is no prospect for many a long day of any such large output on commercial aerial transport. It is merely necessary to recall that our total expenditure on merchant shipping is a mere fraction of this to see the absurdity of apprehending and legislating as if we were to have this immense user of aircraft. There is no slightest probability of any nuisance in excess of what little we suffer to-day, even if we had, which I see we shall not have, an aerial fleet of this magnitude.

I have indicated the need for restraint in law making, but there is also need for positive official action, if the bells that ring in peace are not to sound the knell of aerial activity. The Allies must, during the war, frame a joint policy as to the tolerance of each other's trader and postal aircraft, and agree to air routes throughout the parts of the world which they control. With the large expanse of our colonies and our own industrial and postal importance, we have much to offer to the Allies which will be a valued equivalent for that which we shall obtain from them in the way of alighting rights. Living in an island, and accepting, as we must accept, the proposition that the most significant section of aerial transport will be outside the confines of Britain, we need that our Allied neighbours shall extend, not only tolerance, but welcome to our machines when engaged on their transport work. We and our colonies should have to be prepared and, I believe, are prepared, to extend a corresponding welcome to their airmen at home.

International agreements, even though simple in subject-matter and non-controversial, are always long drawn out. Everyone who understands factory organisation will agree that we cannot afford to wait until after the war for these parleyings to begin. Our aeronautical organism will assuredly become disintegrated too quickly. If we can get four or five willing men round a table to agree to admit aircraft mutually, to register them, to agree to simple preliminary rules of the road, and to agree that their respective countries should initiate a few lines of landing-grounds so as to constitute safe routes, the early days of trade flying have little more to ask for from the Foreign Offices of the world.

No doubt in some four or five years of active aerial transport organisation work the paltry fifty or hundred aeroplanes of our early post-war efforts at transport and travel will have grown up into a significant carrying trade for high-speed work, large quantities of aircraft will have been used for commercial purposes, and it will be found useful to introduce, and there will be experience enabling us effectively to introduce, valuable regulations for the protection of passengers in aircraft, and the public on the ground beneath. At the present day it is clear to all who have eyes to see that no adequate knowledge exists on which to frame rules with discrimination and without grievously hampering technical development.

I can imagine a legislator winning a round of applause from the *inane vulgus* by driving a hard bargain with the wretched trader, who, in the face of starvation, might accept any regulations, however hampering, in exchange for the means to live. I can imagine the imposition of tests of airworthiness, strength tests, the enforcement of hobbies such as multiple engines, silencers, special alighting gears, the carrying of parachutes, fire extinguishers, wireless equipment for calling for aid, and countless other things, which may, no doubt, come in their own time, but which would clog the versatility of the engineer, and for years condemn to unproductiveness the nascent industry of air travel. The payment of an army of inspectors would be put down as encouragement money, and would be a charge against the aeronautical vote. A landowner would ask for the power to capture the flyer who has most reluctantly alighted on his ground. He might ask for a law allowing him to impound the aeroplane, on the chance of his registered number being inauthentic, and so secure payment of the damages which he wishes to claim.

It is just possible that regulations of this sort might meet with support as much as support is at present accorded to the twenty-mile speed limit of the motor-car. They would be next to impossible to remove, though they might be demonstrably hampering the aircraft development of the country to an enormous extent. The intentions would be good, the desire would be to secure that only the best aircraft were used, and that the public suffered no injury by its use. It was for half a century thought that the public could suffer no injury by the four-mile speed limit being imposed on mechanical traction! Later it was thought that as a twelve-mile an hour speed limit was ample for a coach and four, it must be an ample speed for a car, and so the automobile industry passed to France and Germany, in spite of the fact

that the first car plied for hire in England early in the reign of Queen Victoria, when there was *no* speed limit.

Let us rest assured that the amount of civil aircraft will for some years be so much less than the amount of military aircraft now existing, that the total of damage to property and inconvenience to the public, which we at present know to be small, will be much further reduced in proportion to the lesser numbers, the future technical advances, and the less strenuous conditions of manœuvring imposed on peace aeroplanes

Labour.—Among the expectations based on aerial transport and travel are those of employment for individuals throughout the whole social scale, as well as officers and men from the Army and Navy. Our producers, and therefore their employment of labour, depend on the bodies which employ aircraft, viz.: (*a*) Primarily the Air Force; (*b*) foreign buyers, nations and colonies; and (*c*) companies instituted for transport and travel, including postal duties. All these bodies need labour, and all are interested in continuing harmonious relations between those who direct the work and those who manually carry it out.

It has been suggested that since the aircraft industry is a new industry, an exceptional opportunity exists of introducing a totally new atmosphere of harmony unembittered by the old trade quarrels. This is most desirable, but the novelty of the technics of aircraft has not *in fact* eliminated the old trades at all; on the contrary, it has developed the demand for these "tradesmen." The aircraft industry is not a new trade in the sense in which that word is used by the world of labour in the phrase "Trades Union." The aircraft industry includes members of almost all the engineering trades, as well as important additional trades, such as wood workers, carpenters, organ builders, cabinet makers, fabric workers, etc., and it is necessary for that harmonious relationship to be established between employer and employee, in spite of the fact that the history of all the old trade differences will unavoidably be also the history of the persons and corporate bodies imported into the new industry, with this addition, that a trade quarrel on the subject of organ pipes or on the piece-work price of chairs, may mean a stoppage of aeroplane work, owing to the newly imported craftsmen holding on to the old unions.

Again, it would be unintelligent to pretend that aircraft making can be developed under a compact between employees and managers which shall guarantee continuity of employment for all the manual workers in exchange for a continuity of labour supply to the other. The difficulty is a fundamental one, and perhaps is a worse difficulty in the aircraft industry than in most others. It is this. The technical developments of the art, the unforeseeable shortages of material, and the unavoidable changes of method and of materials, tend, let us say, at one time to the employment in an aircraft factory of 50 per cent. of wood workers and 30 per cent. of steel workers, and there is no human authority who can with sanity pretend to say that in some brief time these proportions will, or will not, be widely changed. If steel or aluminium were to form a greater part of the structure than they do now, because of safety, or diminished fire risk, or what not, any agreement with the wood workers' union for continuity of their employment would install them as a paid but non-working body of pensioners on the industry. Alternatively, British aircraft, hampered by such an agreement, would remain locked in its old technical groove and be debarred from adopting the devices and inventions which throughout the rest of the world would be improving the machine. Surely a hopeless prospect for a technical service required for war!

It is clear, then, that the agreements between manual and brain workers on aircraft must be part of the general agreement on which our new millennium is to be based.

Employment of Soldiers and Sailors.—The industry will, even when the most strenuous efforts have been made to save it by such continuance of air service orders as are at all possible, and when such aerial transport work is started as may be decided on, still be cut down drastically. Hence very great disappointment will be spared to many a good man by realising thus early that there will be no expansion of employment on aircraft which will absorb them wholesale, but rather a manifold shrinkage.

Accidents.—It is unfortunate that the chief contact which the public of England makes with aeronautics is in relation to accidents and casualties. The achievements appear, it is true, but it is almost impossible to visualise them save perhaps in the case of an occasional flight of unusual distance, such as the recent 3,000-mile flight from London to Constantinople, or between London and Turin, and these things appear to be disconnected items giving no

impression of the hundreds and thousands of miles of continual flying which is taking place. These show flights are few, not because they cannot be frequently achieved, but because war does not provide for show and *réclame*. The public cannot by a mere lecture be brought to the point of view which is standard with those who have been really familiar with aircraft; we are so imbued with its utility and versatility, that we are no more discountenanced by occasional breakages than we are deflected from hiring a taxi by seeing a sideslip against the kerb. Those actually engaged in design, who naturally need to use every element of experience which accidents may bring to enable them to perfect their work, are anxious to study and analyse these occurrences.

Air accidents can be divided into groups for the purpose of their study, and when we proceed so to divide them we find that by far the largest category includes those which are due to the two following circumstances: (1) The absence of landing-grounds distributed in easy stages to which a flyer can turn for refuge, if his engine should stop; (2) the inexperience of flyers themselves, since the majority of the experienced have been drawn off to the war. If we remove from the records of accidents, other than tuitional, all those which could have been avoided were these causes non-existent, the residue would be less significant in *fact*, and vastly less significant than is the *impression* abroad. Beyond this it is still reasonable and advantageous to subdivide the causes of this residue of accidents into classes, so that attention should be drawn to that which may be eliminated, be it in design or in handling.

Of the remainder, the most important is what is commonly called "Pilot's error." This does not imply that he is blameworthy. In war, manœuvres which are definitely hazardous are necessary; people may be surprised to hear that to loop the loop is a useful war manœuvre which may greatly puzzle an antagonist in the air, since the looped path takes the place of the expected forward movement, and therefore falsifies the aim of the adversary, or throws out all his estimate of the direction in which to fly for purpose of intercepting him. Another manœuvre, known as "spiralling," or "spinning," if contrived to give the impression that the aeroplane has in fact been thrown out of control, is one of many ruses for breaking off a fight. The learning of these manœuvres must be achieved before they can be used in war, and tends to swell the number of broken machines. Rapid diving, such as might be made in an attack on observation balloons, may similarly be a cause of accident until judgment is acquired in the method of "flattening" out of the dive. Even to describe a *very* small circle in a horizontal plane implies unusual stress on an aeroplane, if accomplished at high speed. None of these manœuvres are called for in trader work, while, to add to the comparative safety of the peace aircraft, we can appreciate the effect of removing the war demand for high performance and speed. Under fire and pursuit safety comes from lightness and manœuvrability, as much as and more than it does from strength and solidity: in trader work the conditions are largely changed if not reversed.

Aircraft travel and transport therefore will, if landing-grounds are provided, not be exposed to any of the risks above named, and accordingly from the list of accidents which occur to-day we must eliminate almost all these in any prognostication as to the future safety of flying. Before such an audience I need not belabour the so-called *air pocket*. It never did exist, and generally there seems to be little probability of any aeroplane, even when designed on the factor of strength used to-day, with the limited science of to-day, being broken in the air under the conditions of aerial travel.

Much need not be made of the fire dangers on aircraft, for when the matter is regarded dispassionately, the fire risk by actual experience is small. Of the fires which have occurred since thousands of aeroplanes have been turned out per month, the large majority have arisen when the aeroplane has struck the ground and the petrol vapour from the broken-up tanks has come into contact with a spark. Now this breaking-up of a machine on the occasion of a forced landing again becomes a rare occurrence if the line of landing-grounds suggested for aerial routes is provided. Most of these smashes, some fraction of which have resulted in fires, have occurred by reason of the flyer holding up his machine unduly long in his search for a suitable place to alight in a country where no provision for alighting exists.

Of the mechanical precautions taken to avoid fire, we know that already it has been possible to make a magneto which, when filled with explosive vapour and surrounded by it, gives rise to no ignition of the mixture. We have also learnt that the back-firing or "popping" of an engine into the induction pipe which throws a flame back can be made innocuous by drawing

the air supply of the engine from outside the body work. This, indeed, is standard practice to-day. The use of electrically heated clothes, called for by fighting at heights such as 20,000 ft. will not be normally desirable, and as for appliances for wireless telegraphy, which will have their place for giving trader craft their direction and for calling to the ground, they will not under peace conditions impose any risk of fire which cannot be circumvented. In general the standard of safety from this point of view will be automatically enhanced in all transport work. Carelessness, such as makes people bring matches into a T.N T. factory, cannot be expunged from the human race, but this class of occurrence need not disconcert us at all. In filling up with petrol there is the chance of spillages, and no doubt every aerodrome should be equipped with portable fire-extinguishers of light weight made available at filling points, and no doubt also all larger aeroplanes will carry one in an accessible position, until the proved absence of utility causes them to be relinquished.

The accident, if it can be so called, of losing one's way in a fog will be far less likely to result in disaster, when, to quote it once more, there exists a multiplicity of landing-grounds, because, on the one hand, no fog has been found to extend more than a very limited height, say, 700 yards maximum, and, on the other hand, because we now know that fogs are quite local in their occurrence at any one moment. A befogged flyer, instead of alighting through a foggy patch, merely moves a little further on before landing. This does not imply that projects for signifying to a flyer who is above the fog the correct position of his aerodrome by pilot balloon or raised lights are to be discarded, but this is not the place to deal with that point.

Parachutes are spoken of, but by many flyers are not thought particularly desirable. We know that at present they require a height of some five hundred feet to open out and afford the safety which they appear to offer, and it is usually below these levels that the flyer becomes convinced he is to be exposed to some risks, say, by the conditions of the ground together with the stopping of his engine which causes him to alight. One would have to be very seriously out of touch with those who fly daily and really know their job, if one continued in the impression that numbers of accidents are the inevitable concomitant of aerial travel, and it is sufficient to say that any such opinion may be dismissed as one which has arisen from the peculiar conditions of press publicity in war and the exclusively high pressure and high performance conditions of the development of aeronautics up to to-day. The lack of contact of the public with the serious and successful work which has been achieved has already been mentioned.

Research.—It is possible that someone will question the need for research and for State endowment thereof; it may be said that we are well on and can now trust to practical developments, since root and branch retrenchment of expense is called for. This is a complete *non sequitur.* If cheap progress is wanted, the cost of progress is enormously reduced by making and testing models two feet wide instead of making structures of a hundred-foot span. The ratio of cost is as £10,000 to £50, and it is the £50 scheme which I am advocating. I cannot give a list of researches, but ask you to consider the following examples. We need the scale corrections from model parts to full size; we need to test propulsive mechanisms, without building them; we must know the value of new wing sections; of reflexed wings; of hinging the flaps for controls; we must, in order to get any aeroplane stable, know the movement of the centre of pressure on the wings when the attitude of flight is varied; we must study the effect of vibration on structural parts, etc.

We are aware that the great utility of aerial travel is speed, that the great enemy of speed is head resistance, and we must be able by simple model tests to forecast the speed which will be attained by a given design. We must be able to know, before we introduce a variation in design, the amount of economy of resistance which can be made by altering structural parts. All this class of work can be effected in the wind tunnel, and already most serious aeronautical construction firms are equipping themselves with a wind tunnel. Probably the greatest value of such equipment is its educational effect. The wind tunnel has fought its way to the front, in spite of much opposition, and it is still to be recognised that unless its indications are interpreted by skilled persons grave blunders will be made, but this in no wise detracts from its utility when properly employed.

We are aware that the thermal efficiency of engines employed on aircraft is as high, in spite of their small size and weight, as the efficiency of Diesel engines giving thousands of horse-power. Yet this figure is only 30 per cent., and by research alone can we hope to obtain an extension of this percentage. The study

of airscrew efficiency, the effect upon it of the body, the means for making airscrews smaller than they are at present, and thereby simplifying the whole outline of an aeroplane, is a matter which research must tackle. The use of new alloys, of new methods of totally enclosing the flyer in an aeroplane, new methods of housing the landing gear, so as to get rid of its head resistance, the protection of the fabric of the wings from disintegration by ozonisation due to actinic light, all these and countless more matters can only be economically and expeditiously studied in laboratories equipped for the purpose, they will effect enormous economies in aeronautical upkeep, and aero research must be pressed on and financed after the war.

Broadly, it may be said that air transport will not develop save by taking a line of footprints given by research. To say that we want it, does not by any means ensure that it will proceed apace as it should. Research of various kinds is remunerative in two different ways: (*a*) quickly; and (*b*) eventually. Those studies which conduce to (*b*) rarely produce (*a*) a quick return. On the other hand, researches which afford us (*a*) are very likely indeed to be remunerative both quickly and eventually.

If we now subdivide the various researches which might forward aeronautics into two other classes—those (*a*) which result in some proprietary advantage to the inventor, and those (*b*) which have a general effect on progress, and which are not susceptible of being privately protected—we find that there is every inducement to the research worker to concentrate upon the class of improvement which I have called (*a*) in each of the above pairs of groups, that is to say, the device which can both be made proprietary and which is remunerative quickly.

This must, unless we are very foreseeing and courageous, operate to deflect research workers from the other and frequently much more important class of study, viz., those which are of *general* application and those which are eventually of great money value to the whole of the industry, whether of construction or of transport.

Patent laws stimulate advancement by providing that there shall be a reward, and that all and sundry shall not be able to possess themselves of the fruits of one man's labour and thereby dispossess him. Means must be devised for securing that the British industry as a whole shall not be tempted to exclude from its study the great groups which I have classed as (*b*), which are so frequently not protectible by patent; and this business falls naturally to the new Department of Scientific and Industrial Research, who will no doubt find the hearty co-operation of the Society of British Aircraft Constructors and the Aeronautical Society. It is for the public to see that the determination towards progress exists, and then the outcome will first of all be the necessary funds, and thereafter the harvest of results and economies.

The Air Board has formed a Civil Aerial Transport Committee, which is engaged in considering these and most of the other matters dealt with in any such discussion as this, and if they recommend active steps to be taken, let us hope that there will be firm public support for any expenditure and assistance which shows proper foresight, always with the considered approval of the new Air Minister.

Education.—It is more than probable that by far the most effective step towards industrial peace, with which is bound up much more than ever the healthy development of our aerial fleet, is education; and this aspect of the matter forces us to include what is sometimes overlooked in technical circles when speaking of education—a good foundation of sociological and ethical subjects, as well as technical information. Perhaps one of the most important reasons for developing this side of education is that it will give the average reader a more critical outlook upon the average newspaper, and its somewhat unguarded statements. The effect of this critical outlook will no doubt be that a far higher technical standard and a more cautious statement of alleged facts will be developed, and in this way the educational effect of the press will react to further the educational standards. It will not, we hope, be possible, a few years after the passage of Mr. Fisher's Act, for any person who pretends to a hearing to claim that there is a pool of wealth of limited total from which each and several draw as much as they can. That illusion is the foundation of the impression that the employees suffer by the employer being successful, and we shall all gradually come to accept that by restricting the production of wealth we diminish the chance we individually have of being wealthy.

The indirect abolition by Mr. Fisher's Act of the blind-alley occupations, will have also the effect (since we have decided to be governed by a body which includes many of those who live blindly in blind alleys at present) that a more farseeing electorate will have charge of our destinies. So far as the hand-workers

in aircraft construction are concerned, they do not differ from the engineering trades generally, and the educational scheme which is good for the skilled fitter or carpenter is good for the aircraftsman. In the higher branches, *e.g.* the aeronautical designer, what is first wanted is a good engineering and sociological education, to which are to be superadded the specialities of his calling, a business largely to be achieved by familiarity in college or university with the work of the wind tunnel and whirling arm.

Routes.—One of the things wanted now is some inquiry made experimentally by actual flight for the purpose of determining the best aircraft trader and postal routes which may be useful and eventually payable. London–Paris has been suggested, with extension to Marseilles, Turin, and Egypt. Links between capitals have also been spoken of, and links with India and South Africa, etc. Short runs will probably come first. In all short distance runs the problem is complicated when the existing rail and steam facilities compete. There is a marked advantage for aircraft every time that transhipment of any kind occurs on the ordinary means of transit. This favours London–Paris and London–Dublin, for example. Similarly, and for similar reasons, whereas no great advantage might be gained by a London–Glasgow route, where the train travels at fifty miles per hour, and the journey can easily be done during the lost hours of the night without the traveller being roused from his sleeping berth, we shall find that cross-country journeys, those involving changes of train, waiting at stations for connections, will be instantly eclipsed in comfort and speed by aerial travel and aerial mail deliveries. One could suggest Cardiff and Newcastle, or the like.

I do not think that much is to be gained by suggesting routes at the present moment, unless we propose to permit a few machines to be withdrawn from war service, and then by using a few pilots who are for one reason or another not fit for war service, explore the practical possibilities of such transport. I think it far better to start by carrying newspapers and letters, and packets, rather than passengers at first, for every reason. The routes will be unknown to the pilots, their experience may perhaps not be great—the advertisement expense needed to summon passengers to support the trial cannot usefully be made in war time, and, generally, it is not desirable, save in exceptional case, to expend petrol for personal travel, or to expend money in adapting designs to passengers' comfort. Yet if this comfort were omitted, a false impression of the facilities to be afforded would easily get spread abroad.

I do not know whether certain types, whose performance is below the ever-rising requisites for war could be made available, but I should have thought that with good will they could be managed, and if so, the experiments made in war time would help us to start *quickly*, on declaration of peace, that which might eventually help to create orders—only a few it is true, but still a small fraction of what is wanted for the maintenance of the production factories.

Speed.—I am inclined to endorse Mr. Holt Thomas's view that, if we consider the average wind speed as thirty miles per hour, sometimes with us and sometimes against, we shall need machines whose own air speed is 120 miles per hour, in the case when there is any competition with other means of transport.

On cross-country journeys far lower speeds will be vastly faster than the existing systems, and will at once command attention.

As we know, 120 miles per hour is a very ordinary speed to-day for aircraft, and offers no technical difficulties in alighting—indeed, Captain Green's interesting forecast, under certain conditions which he laid down, of an aeroplane to travel at 240 miles per hour, did not appear to raise any feeling of doubt or hesitancy at the Aëronautical Society about three weeks ago—though a similar audience in 1911 was very sceptical about the advisability of introducing, even for military purposes, my proposed speed of seventy-two miles per hour. This gives us an idea of the changes which have gone on in men's minds by legitimate extrapolations from the actual achievements with which they are familiar.

I have nearly finished, but before doing so I must once more reiterate that the most hopeful estimate for immediate aircraft transport and travel does not save the situation. There must be Governmental action to maintain the country's productivity and designing capacity for military and naval aircraft in the first place, and as the mainstay of the country's factory organisation.

In conclusion, it is only half a truth to say, with Frederick List, "The sea is the high street of the earth. The sea is the parade ground of the nations. The sea is the arena for the display of strength and enterprise of all the nations." There is now the air. A great instrument of power tending to peace and usefulness and good will can be designed in a week, if only a British, a French, an American, an Italian plenipotentiary

could be empowered to sit round a table. That instrument is the aerial way. Its regulations must not be founded now upon speculation, they must be evolved later upon experience.

All the Allied nations desire the same thing, all are agreed that just as in time of peace we must prepare for the catastrophe of war—so in war we must prepare our thoughts and plans for the cataclysm of peace. The word is used advisedly, for a very sinister situation will develop in the world of aircraft during the hiatus which first was publicly indicated, I think, by myself, in the discussion on Mr. Holt Thomas's paper before the Aeronautical Society, and which Lord Cowdray himself promised to make every effort to bridge.

DISCUSSION.

Major S. Heckstall Smith agreed with the suggestion made at the end of the paper with regard to immediately employing aeroplanes for civil purposes. They were already being used in France to carry mails, and the same practice should be adopted in this country as soon as possible. Those employed in aeroplane construction were afraid that after the war they would be left without employment. If they were assured that they would be able to continue their aircraft work after the war they would be glad to do so, but they were so afraid of the hiatus between any commercial work and the end of their war work, that they would all turn their thoughts and plant to other engineering work. That would be a very unfortunate thing for the country, and it was therefore of the utmost importance that aeroplane builders should be told at once what their prospects would be after the war, and the powers that be should be urged to decide the matter promptly.

Mr. Harry Harper thought it would be a very good plan to call an international conference between the Allies, before the end of the war, to frame some simple rules of the air, and also to discuss the laying down of certain aerial routes. It would be very difficult to make any progress until that was done.

Captain Swinton endorsed very heartily all that the author had said in his paper. It might be of interest if Colonel O'Gorman could give some information about the rate of depreciation which was to be expected on commercial aeroplanes. That depreciation would probably be a much more important factor than the cost of fuel. He had heard all kinds of estimates given, from $33\frac{1}{3}$ to 180 per cent. per annum.

Mr. J. F. Crowley said he had been very much interested in Colonel O'Gorman's paper. With regard to aerial routes, he thought an air service might be established between Galway and America for the purpose of carrying mails, thus considerably shortening the time taken to carry letters between this country and America. It would be very interesting if the author would say what he thought of the Zeppelin as a possible rival to the aeroplane. Before the war, a friend of his had been appointed by the German War Office as designer of the rotary apparatus for the Zeppelin airship, and that gave him an opportunity of visiting some of the Zeppelin sheds and seeing the vessels in action. He was very much struck, as an engineer, with the extraordinary perfection of their design, and since then they had, of course, been greatly improved. The shape of the body had been altered so as to reduce the friction, the speed had been increased, and altogether the Zeppelin had made very great advances. In working out any scheme for the commercial development of the aeroplane, it was very desirable to know from experienced men like the author what position lighter-than-air machines were likely to occupy for commercial purposes.

Mr. Walter F. Reid did not quite agree with the author that the nuisance possible in connection with aeroplanes was negligible. Personally, he thought that nuisances should be very seriously considered, as there was nothing more injurious to the progress of commercial aerial navigation than opposition on the part of individuals who might possibly suffer from some slight nuisance. The development of the motor-car had been greatly impeded in that way. A large number of aeroplanes passing continually over a certain place might easily give rise to complaints from people residing in that district, and there should be a central fund out of which to compensate them for any injury, such as the fall of aeroplanes. With regard to Captain Swinton's remarks about the cost of the renewal of aeroplanes, it should be remembered that they did not require an expensive line of rails, such as was needed by railways, and he thought aerial transport ought to be extremely remunerative, both to the public and eventually to those who constructed and ran the machines. The latter might very well afford to pay a small subscription towards the compensation fund that he had mentioned. The author had referred to the injury that might be caused to aerial transport by technical legislation, and it was quite true that such legislation might hamper the whole progress of Great Britain in regard to a new industry in which she ought to lead, as she did in the case of the locomotive industry. Already a Bill had been introduced into Parliament to propagate the system of mismanagement that had been going on in the different Government departments with regard to the purchase of materials, and another Bill that was now before Parliament contained a clause by which the Comptroller of the Patent Office was to be the judge of whether an invention was worked on a commercial scale in this country.

He was to have the power to preclude the patentee from himself working or using his invention. Any capitalist could say that a certain invention had not been worked on a commercial scale in this country, and he could get the Comptroller to hand over the invention to him on payment of a royalty, the inventor being thus precluded from working his own invention. That was not the way to encourage invention, and under laws of that kind this country could not possibly compete with the United States or Germany, or any other country where the inventor was properly treated. Research in connection with the aeronautical industry was of the very greatest importance. He had been chairman of several of the experimental committees of the Aeronautical Society, which found out many things that had not been touched since, but which offered a vista of enormous improvements in the flying machine. For instance, the propeller of the aeroplane was not, in his opinion, the best that could be evolved; it was wasteful in power, and had other great disadvantages. It should have a certain amount of elasticity which would enable it to be adjusted to the power that was being put into it, but at the present time the propeller was rigid, and was not adjustable at all. With regard to the utility of research, he would like to call attention to the very useful work that had been done by the Advisory Committee on Aeronautics, work that had helped the industry very much indeed. He was the originator of that committee when he was a director of the National Physical Laboratory, and it had done very good work, although it did not at the beginning do what was expected of it in regard to full-sized aeroplanes. He hoped that similar research to that carried out by the committee would be undertaken on a large scale. With regard to the standardisation of aeroplanes, he was an opponent of standardisation if it meant that for four or five years the same kind of machines had to be ordered, made in exactly the same way, with interchangeable parts. That meant simply stagnation. The committee entrusted with the work of standardisation should meet once a year, or even more frequently, and consider where the standard already adopted was defective, and where it could be improved, and then, with the agreement of all the makers and users of aeroplanes, those alterations should be made at once. If the different kinds of machines were limited in number, and all the makers interchanged their ideas, as they might do, then spare parts could be obtained at all the different stations where aeroplanes might alight, which would be a great advantage. He had devoted a great deal of attention to the subject of landing-places for machines. In England, if the authorities would only use them, there were better methods of illuminating aerodromes at night than were available in France, although France was formerly ahead of this country in that respect. The stations at which aeroplanes were to alight should be from the very first planned at regular intervals throughout the whole country, in connection with the population and the adjacent towns, etc., and a committee should be appointed to decide where the stations were to be erected, in order to avoid the more or less haphazard method of building stations that had been adopted by the railways when they were first constructed.

Mr. Leon Gaster said that the paper was of great interest to him, as he was a strong believer in the future industrial possibilities of the aeroplane. He recalled that, when present at a paper read before the Society by the Rev. J. M. Bacon in that very room about eighteen years ago, he had expressed the opinion that the solution of the air problem would be found in a heavier-than-air machine, rather than one depending on the buoyancy of a gas-envelope. Time had proved the correctness of this observation, though it was made five years before the flights of the Wright brothers and the subsequent development of the aeroplane. Whilst agreeing with the proposition of the author that everything possible should be done now to prepare for the future use of aeroplanes in the manner indicated, and appreciating the practical way in which he had dealt with the problem, Mr. Gaster thought that Colonel O'Gorman had rather given the impression that he cold-shouldered the idea of passenger traffic. That was, in his opinion, a development that was bound to come. Although the experimental difficulties might be considerable, advantage might be taken even now of the facilities offered by the Department of Scientific and Industrial Research for investigations in this field. He believed that the future possibilities of aircraft for peace purposes might prove more wonderful than their present applications for war. He looked forward to the time when science would once more be put to its proper use, and when the aeroplane would become a connecting link between peoples instead of an instrument for the indiscriminate slaughter of non-combatants in defiance of the laws of humanity.

Colonel O'Gorman, in reply to the discussion, said he did not mean to throw cold water on the eventual prospects of civil aerial transport, as Mr. Gaster had suggested. There was no question to his mind but that commercial aeronautical development was bound to grow, but if we simply felt convinced that we had a nice healthy infant that would grow up without any trouble on our part, then what would happen would be that that infant would die from neglect. It was necessary that it should be fostered with the utmost care, and that immediately. He was glad no speaker had complained—as he rather expected some might do—that the question of civil aeronautics should not be discussed during the war. After all, we were fighting the war for the purpose of carrying on the existence of this community, and if we failed to think about the business of this community during the war we should fail to exist afterwards. If the war was

ended to-day, then the aircraft industry would die; aeronautical construction would cease, and there would be nothing for the aircraft factories to do. He strongly urged that steps should be taken at once in preparation for the time of peace. With regard to the question of nuisance raised by Mr. Reid, it was true that if there was a nuisance, however small, arising from aircraft, there were sure to be complaints. Half-a-dozen people complaining of the noise in the morning, however, was a very small matter compared with the advantage of having the whole of England protected against a sudden aeronautical attack, should war ever break out again. He did not wish to suggest that the nuisance was negligible, because it certainly deserved consideration. It consisted mainly of noise, and sound was a science about which very little was known at the present time, and which was greatly in need of research. He was afraid that legislation might be introduced to treat the noise of aeroplanes as an adequate cause for imposing regulations which might very easily strangle the whole aeronautical business. With regard to rigid airships, he had always upheld airships ever since the first moment when he had an opportunity of building them. Not very long before the war he had the good fortune to make a trip in a rigid airship in Germany. It was interesting to know that per pound of useful load carried an airship was to-day a cheaper implement than an aeroplane; that did *not* imply that, if it was desired to carry goods from one place to another the cost per pound of goods carried was less in the case of the airship, but only that the prime cost of the airship alone was about one-eighth or one-ninth less than the cost incurred in the case of the aeroplane. There were, of course, other factors to be considered in comparing the two; for instance, when an airship alighted it required a large landing party. The question of the airship *versus* the aeroplane was a complicated problem, on which profound study must be made before one could even guess at the solution. Until aeroplanes could be adapted for long-range sea scouting, this country would require to use airships for that purpose. He thought the suggestion made by Mr. Crowley of an aeroplane mail service between London and Galway, to catch the American mail ships, was a very good one. With regard to the rate of depreciation of aeroplanes, it must be remembered that in time of war the depreciation was very much greater than it would be in time of peace. Aeroplanes used on war service were exposed to all kinds of dangers, and the life of such an aeroplane was probably only about one-and-a-half to two months. Aeroplanes employed in civil work would probably have a much longer life, but the question of their rate of depreciation strengthened his hands in the plea he put forward for the necessity of experimenting with commercial aeronautics at once. Perhaps the fact, mentioned by Major Heckstall Smith, that aeroplanes were already being used in France to carry mails might hasten the time when England would attempt something similar. As regards the suggestion for a central fund to repay the public for damage received by an aircraft alighting on their crops, etc., he saw no reason why the owner or flyer of the craft should not be held responsible to repay in full the damage, without any central fund. That was not the class of legislation he objected to. He had no desire that the aircraft transport industry should escape this legitimate burden. What he did object to, and actually apprehended, was there should be regulations framed which would be intended to protect, and would protect a few householders from, for example, the noise which they might suffer from by being near an aerodrome. The noise of a passing aeroplane was much less than that of a railway train entering a station, yet we found that it has been well worth while to bear the local drawbacks of this noise to individuals residing on the railway line for the sake of the enormous advantage to the community of having the railway service. Similarly, the aircraft noises, which were an annoyance just now, were objections outweighed by the advantages of speedy transport. Legislation, prescribing, let us say, some ridiculous height of travel above the houses near an aerodrome, might secure the absence of noise, not only because of the height of flight, but because of the killing of the aircraft business and the consequent absence of flying. This last was the consummation to be guarded against, and he still maintained that the noises due to aircraft about the country were to-day a negligible source of nuisance compared to the advantages. He thought Mr. Reid was unintentionally unfair in blaming the National Physical Laboratory for not doing full-scale research work on the aeroplane, for the reason that full-scale work had never been referred to them, and they had not, nor ever had, any means or staff for dealing with it.

THE CHAIRMAN (the Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.), in moving a vote of thanks to the author for his interesting paper, said he was very much interested in the question of technical legislation with regard to aeroplanes, because such legislation had prevented the progress of the motor industry for very many years, and at a later period had acted very detrimentally in the electrical industry. In this country we were so anxious to protect the individual that we often stifled progress. The Committee on Scientific and Industrial Research had now considerable funds placed at their disposal, and were trying to do all they could to assist unremunerative researches. Last year the committee spent £12,000 on experiments, and this year they would probably spend a very much larger sum.

The vote of thanks was carried unanimously, and the meeting then terminated.

THIRD ORDINARY MEETING.

Wednesday, December 5th, 1917; Alan A. Campbell Swinton, F.R.S., M.Inst.C.E., M.I.E.E., M.I.Mech.E., Vice-President, and Chairman of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Berwick, F. W., London.
Delpech, Reginald, London.
Hackett, W. W., Birmingham.
Hall, Robert Swainson, Portuguese Congo.
Lake, Joseph Lenegan, London.
Lambert, Arthur Reginald, Sevenoaks.
Laws, Robert George, London.
Samuel, Henry, London.
Seth, Mesrovb Jacob, Calcutta.
Waring, S. J., London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Aplin, William, Assoc.Inst.M.M., Queensland, Australia.
Armstrong, Ernest, Haydon Bridge, Northumberland.
Banatvala, Curtsetji Jamsetji, B.A., Bombay, India.
Bayley, Victor, C.I.E., Assoc.M.Inst.C.E., Simla, India.
Bhándare, Rao Bahadur S.T., Inspector-General of State Records, Gwalior, Central India.
Blair, Lieut. John Hamilton, R.N., D.S.O., Submarine Depôt, care of G.P.O., London.
Clowes, William Archibald, Ditton Hill, Surrey.
Collier, Harry Samuel, Buckland, near Betchworth, Surrey.
Cox, W. Howard, Cincinnati, Ohio, U.S.A.
D'Abreu, Aubyn Reginald, Mesopotamia Expeditionary Force.
Dhruva, Maganlal Dhaneshwar, Rewakantha, India.
Gwyther, Harry Earlston, M.Inst.C.E., Rio de Janeiro, Brazil.
Hamshaw, William Hamlin, J.P., London.
Hancock, Walter Charles, London.
Hay, Leslie, Messrs. Finlay & Co., Ltd., Calcutta, India.
Henriques, Elias Cosmas, A.R.I.B.A., Bombay, India.
Hutchinson, C. M., B.A., Pusa, India.
Jack, Robert Ernest, I.C.S., Calcutta, India.
Jennings, Frederick W., London.
Johnson, Arthur Laurence, M.A., Middlesbrough.
Johnson, Harold, Bombay, India.
Jones, F. J. Clinch, Northenden, Cheshire.
Jordan, Frank, Swansea.
Kemp, Walter Lowther, Singapore, Straits Settlements.
Krishnagar, Maharaja of (Kshaunish Chandra Roy Bahadur), Bengal, India.
Kroll, Clifton H., San Francisco, U.S.A.
Laird, James, London.
Lang, Rev. George, Alabama, U.S.A.
Locker, Thomas Cecil, A.M.I.Mech.E., Warrington.
Macdonald, James, Hong-Kong, China.
Makower, Ernest S., London.
Matthews, Dr. Joseph Merritt, East Orange, New Jersey, U.S.A.
Mawson, George Thomas, Bombay, India.
Mews, Walter, Portslade, Sussex.
Molson, John Cavendish, M.D., L.R.C.P., F.C.S. Hayward's Heath, Sussex.
Moore, William Withers, London.
Muto, Sanji, Hiogo, Japan.
Naidu, Mallem Chengalvarayulu, Rangoon, Burma.
Nashipur, Maharaja of (Ranajit Sinha), Bengal, India.
Nicholson, Harry, B.Sc., London.
O'Leary, Very Rev. Peter J., Sligo, Ireland.
Poulsson, Ths. H., Stavanger, Norway.
Richardson, Robert Taylor, J.P., Barnard Castle, Co. Durham.
Rowell, Herbert, M.Inst.C.E., M.I.N.A., Jesmond, Newcastle-on-Tyne.
Ruthen, Charles Tamlin, L.R.I.B.A. M.S.A., London.
Santosh, Raja of (Manmatha Nath Ray Chowdhury), Bengal, India.
Scott, James Lang, Bramley, Surrey.
Shewan, Hon. Robert Gordon, Hong-Kong, China.
Sneath, William H., Ryfylke, Norway.
Solman, Harry, London.
Starr, Louis, M.D., LL.D., London; and Philadelphia, U.S.A.
Tait, William Archer, D.Sc., M.Inst.C.E., London.
Tarlton, Edward Smedley, Barakar, India.
Tobutt, John James, London.
Waite, Captain C. S., C.I.E., Delhi, India.
Wee Guan Toh, Sandakan, British North Borneo.
White, James, Commission of Conservation Ottawa, Canada.
Wilcock, Arthur, London.
Wilson, Anthony, J.P., Braithwaite, near Keswick, Cumberland.
Wilson, Leonard, Washington, D.C., U.S.A.
Wood, Sir Henry Trueman, M.A., London.
Wright, A. J., L.D.S., D.M.D., Perth, Western Australia.

The Chairman, in opening the meeting, said that the lecturer, Sir Dugald Clerk, did not need any introduction from him, as he was well known throughout the scientific world. It was singularly appropriate that Sir Dugald Clerk should give the first of the "Trueman Wood" Lectures, because he

was the originator of the idea of commemorating Sir Henry's long period of service as Secretary of the Institution. Sir Henry Trueman Wood retired from the secretaryship at the close of Sir Dugald Clerk's term of office as Chairman of the Council, and it was the latter's happy inspiration to commemorate Sir Henry's services by the institution of the "Trueman Wood" Lectures.

The lecture delivered was—

TRUEMAN WOOD LECTURE.

DISCOVERY AND INVENTION.

By Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

The Council of the Royal Society of Arts, on the retirement of Sir Henry Trueman Wood from the important office of Secretary, after forty-five years' connection with the Society, desired to mark their sense of the great services rendered by Sir Henry by instituting an annual lecture to be delivered at the Society. This lecture is to be called "The Trueman Wood Lecture," and, in accordance with Sir Henry's wishes, it is intended to discuss some interesting point or problem in connection with the application of science to the needs of civilisation.

Sir Henry Trueman Wood has had a lifelong experience of science in every possible application to the good of mankind. He was educated at Harrow and Clare College, Cambridge, and it is interesting to note that he studied for the Classical Tripos and became Le Bas University Prizeman in 1869. Sir Henry's classical education did not in any way, however, prevent the growth of an intense interest in science and industry, because we find him as early as 1870 engaged in H.M. Patent Office as a Civil Service clerk at the age of twenty-five. Two years later he became editor of the *Society of Arts Journal*, while Le Neve Foster was Secretary. He edited the *Journal* for four years, and in 1876 became Assistant Secretary, and in 1879 Secretary, so that while he has been connected with the Society for forty-five years, for thirty-eight years he has beneficently controlled our destinies. Undoubtedly for nearly forty years the success of the Royal Society of Arts has been due to the ability, industry, and great capacity as an organiser, of Sir Henry, as well as to his vivid interest in every mode of serving our country by the encouragement of scientific industry. In addition to the work of conducting the affairs of the Society, he gave important aid in connection with the Inventions, Colonial, and Health Exhibitions. He was British Commissioner to the Paris Exhibition of 1889, and he received the honour of Knighthood in 1890 for his services in promoting the success of the British Section.

Sir Henry is a skilled photographer, and was President of the Royal Photographic Society from 1894 to 1896. His knowledge of mechanical science is also shown by the fact that he acted as Honorary Secretary to the Mechanical Science Section of the British Association for six years, from 1878 to 1884. He is the author of two important books, "Industrial England in the Middle of the Eighteenth Century," published in 1910, and "The History of the Royal Society of Arts" in 1913.

Sir Henry has led a most active life, devoted to the welfare of his country by encouraging in every way the application of science to all the needs of mankind. It is most fitting, therefore, that "The Trueman Wood Lecture" should be instituted in his honour, and that it should deal with different phases of the development and use of scientific discovery and inventions.

I feel it a high distinction to be requested by the Council to give the first of the series of lectures in honour of our friend and co-worker, Sir Henry Trueman Wood. I have accordingly chosen as my subject the consideration of some interesting matters in connection with Discovery and Invention.

Our distinguished Chairman of Council, Mr. Campbell Swinton, has just given us an admirable address of wide scope dealing with the general history of Science, and accordingly I propose to confine myself to the discussion and comparison of Discovery and Invention in some detail in a manner intended to be supplementary to his interesting account.

DISCOVERY AND INVENTION.

In the present time, when reconstruction problems require a true appreciation of the proper function of Science in the State, it is important to form clear and accurate ideas as to the differing nature of Discovery and Invention, in order that Science may be given due weight in the coming scheme of things. Even scientific men think somewhat loosely on this subject, and often confuse the functions of discoverers and inventors. It is too often assumed by specialists of a certain type that discoverers are also inventors, or at least could be inventors whenever they chose to descend from the important realms of abstract scientific investigation to the—as they think—easier business of producing inventions for the practical needs of civilisation. As a matter of mere fact, discoverers are hardly ever inventors; the type

of brain power which is found in great discoverers is quite different from that of the great inventor.

Scientific research in physics and chemistry is of two kinds: one kind deals with the nature of the phenomena observed, and endeavours to arrive at some soul-satisfying explanation of the why and wherefore of the particular occurrence; the other endeavours to discover hitherto unknown phenomena. Naturally the earlier investigations dealt with known phenomena, and one type of discovery consisted in determining their laws. Newton's discovery of the laws of gravitation dealt quantitatively with the fall of matter from a height, and applied equally to the motion of worlds and the fall of a stone. The facts were known, and the discovery consisted in the determination of the law of the fall and the measurement of a pull at any distance—a few feet or thousands and millions of miles. The discovery, however, of a numerical law does not constitute an explanation of a phenomenon. Gravitation is as great a mystery now as in Newton's day; no explanation has been forthcoming, no possible mechanism has been conceived to enable us to understand the nature of the attraction of one particle of matter for another, either at atomic distances or at the huge gaps of interstellar space. Newton's discoveries supplied the law, but not the explanation. So far science has often been able to supply the law, but never the explanation. Many laws are known with considerable accuracy, but all reasoning on the facts leads up to the contradiction which inevitably follows the closer application of thought to theories of gravitation, cohesion, light, electricity, chemical action, and life; all appear equally inexplicable. The object of the more highly abstract scientific investigation is to find some reasonable explanation of the universe, and this can only be attempted by the close examination of all phenomena and the discovery of phenomena hitherto unknown, then the determination of such laws as can be dealt with by the senses with which Providence has gifted us, aided by the use of special instruments to extend their scope.

The research then consists in weighing matter, measuring volumes, velocities, light intensities, and so forth, which accompany the particular occurrence and attempting to deduce a law. From the law and nature of the action a theory or hypothesis is formulated, either by induction or deduction, which appears to account for some, if not all, of the facts. When the investigation reaches this stage it is usually felt that the phenomena have been explained. So far, however, science has failed as completely on the material side as philosophy has on the intellectual in furnishing us with one complete and altogether true conception of any action whatever. What is commonly called an explanation merely refers the mind to familiar actions in matters which permit of numerical determination. When the new or unfamiliar becomes analysed into familiar constituents the new phenomena are said to be explained. The work of abstract science so far has consisted in the determination of the sequences of phenomena which occur within our experience, and in disentangling in these differing sequences occurrences which are called electrical, gravitational, thermal, etc., referring in fact differing phenomena to a common class.

Although no real explanation of any occurrence has yet been found, this does not prevent us from predicting the effects of alteration in circumstances, because the law is often known, and whether we understand it or not, the law permits us to know what will happen.

Thus, although we have failed to understand gravitation, we can rely on the great law that attraction between bodies varies directly as the mass and inversely as the square of the distance. We can rely so far on the generalisation that within our experience matter is neither destroyed nor created. The great laws of thermodynamics, the mechanical equivalent of heat, and the law of heat conversion, known as the second law, may also be used for prediction. Numerous other laws are used for prediction, and the prediction in the form of an experiment or machine is found to be accurate notwithstanding our ignorance of any real explanation. Practical use can be made of the facts without fully understanding them.

The object of abstract investigation is to endeavour, by questioning nature, to accumulate a sufficient basis of fact and law of sequence ultimately to arrive at some comprehension of the nature of matter and energy in its different manifestations — physical, chemical, and biological. This is the fascinating work of the abstract investigator, and its pursuit is of the utmost importance to mankind, apart altogether from any question of material gain. It is, and should be, conducted without any aim other than true understanding; nothing but abstract truth is its object.

The complexity, however, of all nature is so great that progress can only be made by each investigator devoting his life to a comparatively

narrow field. The world of actions found in the atom and molecule by the modern investigator are almost infinite in their variety, and life is all too short for one man completely to elucidate even a relatively small class of fact. Such work is of world-wide importance in the development of the reasoning power of man, and the hope may be held that in the future our intelligence may rise to enable us to attain a real, if not complete, understanding of the marvellous world in which we find ourselves mysteriously gifted by the Almighty with consciousness of ourselves and our surroundings, and reasoning power at least sufficient to attempt the understanding of our circumstances.

Work of this kind is not usually compatible with the power of invention required to meet the material needs of civilisation. Accordingly we find that the inventor and designer is a man of different type from the abstract investigator. The abstract man must be intensely specialised; the inventor must have a wide acquaintance with the properties of all the materials with which he works, and must also have knowledge of the particular needs of the industry which he intends to improve. His work is quite different. It is true that the inventor may have to investigate part of the science of his subject for himself; he generally finds the sciences involved in any particular problem lacking in definiteness or information just where he requires it, and he often sets to work to determine the facts for himself. It thus generally happens that the science of any engineering subject is never fully developed by abstract investigation, and it usually requires the rise of a great industry to lead to the carrying out of the experimental determinations required for quantitative accuracy in working conditions.

That the work of invention is not usually performed by the discoverer and investigator of new sequences and laws is very evident from an examination of the records of the Royal Society. The Presidents of this great Society, which has had a vital influence on civilisation, are always very distinguished men of science, and almost invariably investigators and discoverers of the first rank. From 1820 to 1915 twenty-one Presidents have shaped the destinies of scientific development from the presidential chair, seated behind the great silver mace presented to the Society by Charles II. in 1662. Of those, however, only four could be considered to be inventors — Sir Humphry Davy, miners' safety lamp and electrolytic decomposition of the alkali metals; the Earl of Rosse, designer and inventor of the great reflecting telescope; Lord Kelvin, inventor of the mirror galvanometer, the syphon recorder, and other instruments for submarine cable work, and also the pianoforte wire deep-sea sounding instrument and the improved short needle mariners' compass, and many other electrical measuring instruments; and Lord Lister, the great medical investigator who applied the discoveries of Pasteur and Metchnikoff to the purposes of surgery, and thus saved many, many thousands of lives. The other Presidents, seventeen in number, include men of the highest genius, of whom may be mentioned Sir George Airy, Sir Joseph Hooker, William Spottiswoode, Professor T. H. Huxley, Sir George Stokes, Sir William Huggins, Lord Rayleigh, Sir Archibald Geikie, Sir William Crookes, and, at the present time, Sir J. J. Thomson. Among them they have largely shaped the science of to-day in astronomy, natural history, biology, physics, geology, chemistry, and the great modern development of the science of radioactive bodies and the study of gases under electric discharge *in vacuo*. These are, indeed, distinguished names of men who have rendered the world service which will never be forgotten. For some reason the list of Royal Society Presidents in the nineteenth century omits two of the most distinguished men of science—Michael Faraday and Charles Darwin—men whose discoveries and researches have influenced all modern scientific thought. Their names, however, are to be found among the recipients of the highest distinction of the Society—the Copley Medal, which has been awarded annually since the year 1731. This brilliant list begins with Stephen Gray in 1731, and ends with the name of Sir James Dewar in 1916—174 names in all. Of these most distinguished men of scientific discovery only twelve can be considered to be inventors. They are: (1753) Benjamin Franklin, (1759) John Smeaton, (1796) Count Rumford, (1794) Professor Volta, (1805) Sir Humphry Davy, (1838) Carl Frederick Gauss, (1844) Carlo Matteucci, (1860) Robert Wilhelm Bunsen, (1868) Sir Charles Wheatstone, (1883) Sir William Thomson, (1902) Lord Lister, and (1916) Sir James Dewar. Curiously enough, the great name of James Watt does not appear in any Royal Society list of awards.

As an interesting matter of mere fact it is evident that a great discoverer and investigator is not necessarily an inventor; some are, but they are few in number. It is an error, then, to assume, as many scientific men do, that men distinguished in abstract research also possess

the power of practical design and invention. It is also an error to assume that the evolution of a great invention follows the course usually considered true and logical; that is, that the abstract scientific investigator discovers the phenomena and determines the laws, and the inventor and designer applies these laws and facts to the practical work. It is also assumed that the original discovery on which the invention rests requires a higher order of mind than that required for the application of the laws when so discovered. It is stated by many scientific men that inventors, designers, and manufacturers are culpably ignorant in neglecting the application of laws already known immediately to practice. The assumption is that application is easy and rapid, while discovery is slow and difficult. A short examination of the course of development of several leading inventions will show the true facts and explain the reason of the frequent disappointment of scientific men in their efforts to apply their science to practice.

Faraday made his great discovery of the induction of electric currents by magnets in the year 1831, and he endeavoured to produce a magneto-electric machine, and he describes several attempts in his Researches. He appears to have nearly approached a successful working machine in the apparatus which he thus describes: "A disc of copper, twelve inches in diameter, and about one-fifth of an inch in thickness, fixed upon a brass axis, was mounted in frames so as to allow of revolution, its edge being at the same time introduced more or less between the magnetic poles. The edge of the plate was well amalgamated for the purpose of obtaining a good but movable contact, and a part round the axis was also prepared in a similar manner. Conductors or electric 'collectors' of copper and lead were constructed so as to come into contact with the edge of the copper disc." Electric currents were obtained from this apparatus, but the first magneto-electric induction machine which reached the market was the invention and design of an Italian, Pixii. It appeared in the year 1833. In it horse-shoe magnets were rotated on a vertical axis, so that the poles passed close to the soft iron core ends of two bobbins mounted above it. A commutator collected the current and caused it to flow in successive impulses in the same direction. This machine was superseded in a short time by Clark's machine, in which the magnets were stationary and the bobbins revolved; the commutator was also improved. The first machine, however, to produce the electric light by magnets was known as the Alliance Company's machine. It was produced in 1849 as the result of the modification of Clark's invention by M. Nollet, Professor of Physics in Brussels, and a workman, Van Malderen. In 1856, Werner Siemens invented and designed a new machine of much greater power for weight and bulk; the leading advance consisted in a shuttle-wound armature of small diameter, but considerable length. Later, Wilde, of Manchester, greatly improved the Siemens machine by substituting soft iron electro magnets to produce the field and exciting the electro-magnets by a smaller separately driven magneto machine. In 1860 the ring type of armature and winding was invented by Pacinotti. This was later developed by the Belgian engineer, Zénobe Gramme, and became known as the Gramme ring machine.

So far the machines proposed used permanent magnets, either to generate current to excite the field magnets or to produce the field itself directly. About 1866–67 Varley, Wheatstone, and Werner Siemens separately, but almost simultaneously, proposed to use the current generated by the machine to magnetise its own field magnets, and this proved to be a principle of first-class importance. The machine depended upon the residual magnetism of the soft iron magnets to enable it to start up, and although the flow was feeble at first, it speedily increased as the current passed through the field magnet coils. Such machines were called dynamo-electric machines, as suggested by Werner Siemens. Then followed the differentiation of *series-wound* and *shunt-wound* dynamos; in the first the field magnet coils were heavy and carried the whole current, and in the second only a portion of the current was so applied. The first application of the self-exciting principle of Varley, Wheatstone, and Siemens was made about 1870 by the English instrument-maker, Ladd. The Gramme dynamo, introduced in 1870, became very successful; it has been extensively used.

Thus thirty-nine years elapsed between the great discovery of Faraday and the invention, design, and application of a moderately successful machine embodying Faraday's fundamental principles. Many inventive and highly instructed minds had shared in solving the difficult problems presented, and the science of the subject was simultaneously studied by many technical experts. Much yet remained to be done; the dynamo was not yet self-regulating, and it was

by no means evident how this could be best accomplished. In this connection I may be permitted to mention an interesting fact. In the year 1883 Lord Kelvin (then Sir William Thomson) had a gas engine of my invention and design fitted up in the University Laboratory to drive a Siemens shunt-wound dynamo for the supply of electricity for lighting his house in the University grounds with the then new Edison incandescent lamps. Lord Kelvin took a great interest, and himself designed the house switches and the special regulating device which he attached to the dynamo in order that the current supplied to the house, which varied with the number of lights in use, should have a nearly constant voltage. Lord Kelvin explained the device to me, and I frequently saw it in operation. To prevent change of voltage with alteration of the output of the dynamo he arranged a variable resistance for the control of the shunt current passing to the exciting field. This resistance consisted of a small wheeled conductor arranged to travel up and down an inclined rail; at each position the appropriate resistance was inserted in the field circuit. The operation was mechanical and very ingenious: a shallow circular vessel was rotated at a low speed; it contained a somewhat viscous oil. In the oil two toothed wheels, geared into each other, were immersed, and a spindle from one of the wheels was carried up to a centre from which the wheels and their spindle and frame were hung; the wheels were drawn to one side of the rotating vessel by a light spring, and a solenoid operated by varying current was arranged to oppose the spring action. When current varied the wheels moved to one or other side of the vessel; when in mid position the viscous oil acted as if gearing into the outer teeth of both wheels, and so the spindle was held stationary; when the wheels passed to one side or the other the outside wheel acted as if geared by the oil to run in one direction to lift the rolling switch and diminish the resistance in the exciting circuit; when in the other direction the switch rolled downwards and increased the resistance. Thus the dynamo supplied the house with varying current to suit the number of lamps in use as required. The apparatus interested me very much, and it worked quite well. Lord Kelvin was delighted with it, and it was used for some years.

Very soon, however, the compound-wound dynamo was introduced, the invention again of Varley and others, and in this improvement the field was supplied with a certain proportion of series winding as well as shunt. The proportion was so arranged that, given constant speed of rotation, the current varied as required, and the voltage of the supply remained nearly constant. The theory of compound winding has also received great attention, and it is now thoroughly understood. In 1883, however, the simple device of compound winding was not an obvious one to the highly-trained scientific mind of Lord Kelvin, as is shown by his use of the ingenious but cumbrous apparatus which I have described. That is a very interesting circumstance which proves that the slow development of the dynamo from Faraday's time was due to inherent difficulties which could not be solved at short consideration by even the greatest of scientific men. It appears to indicate that the step by step progress by trial, testing of results and trial again is a necessary process in the production of invention as well as in the discovery of new facts. Thus, in the year 1884, which saw the introduction of the self-regulating compound dynamo, fifty-three years had passed since Faraday's discovery of the fundamental action on which the great modern industry of electric light and power is now firmly based. Faraday died in 1867, seventeen years before the more advanced application of his work. The whole great structure springs from Faraday's work; the full realisation, however, occupied hundreds of acute inventors and investigators for many years. The application of science to industry was undoubtedly a slow process in this instance. Here, however, we are fortunate in tracing the industry from the discovery of the fundamental fact that a magnet moved relatively to a coil produced an electric current.

In other great inventions the same slow process of development is always found; the steam-engine from Newcomen to James Watt and on to Parsons, followed the same course of step by step improvement, but in this case the engine came into existence before any true theory of the nature of heat was arrived at. These steam inventions belong to a great class in which it may be truly said that the engineer-inventor produced machines which it became the function of the scientific discoverer to explain. What would logically be considered the fundamental science did not exist in either Newcomen's or James Watt's time. Heat was supposed by most scientific men to be material, and chemists revelled in the use of the "phlogiston" theory to account for flame and the effect of many chemical actions. Watt died in 1819, and Carnot did not publish his great paper

on the Motive Power of Heat till 1824, so that Watt died before the beginning of thermodynamics as a science. Even Carnot's work did not throw any very clear light on the relationship of heat to mechanical work, because his reasoning was consistent with the caloric or material theory. On Carnot principles of that date the amount of energy to be obtained from any given amount of heat might be of any value, depending only on the temperature fall. The idea of the mechanical equivalent of heat required the abandonment of the material theory, and, strangely enough, Lord Kelvin, who studied Carnot, was the latest of the great physicists of the nineteenth century to accept Joule's results as announced by him about 1841.

The study of steam and other heat engines apparently gave rise to the science of thermodynamics, which has given us, perhaps, the greatest generalisations known to science, applicable equally to motive power, physics, and chemical action. The first and second laws have been and are invaluable in nearly all physical and chemical reasoning.

Parsons was fortunate in finding thermodynamics fully understood when he began in 1884 his great work on the steam turbine; but with all the help of abstract laws, he found much to investigate in the flow of steam-jets which had not been understood till the time of Laval and Parsons. Even with all the knowledge of the time, Parsons required from 1884 to 1898 to work through the great difficulties of his subject. Here the investigation had to be made on what he as an engineer had successfully produced.

The science of thermodynamics is thus in one of its sides an explanation of the laws of operation of engines already in existence. In the case of the electric light, the dynamo sprang from the scientific discovery of Faraday. In the case of the steam-engine the science sprang from the reasoning on the facts of practice. Here, too, the invention has been of the step-by-step constant invention, design, construction, and trial, and equally constant investigation of the facts revealed by the numerous tests. No royal road is here which would enable the scientific discoverer at once to apply his discoveries to practice.

The long-continued action of many minds is also characteristic of the brilliant progress of the internal-combustion engine. In this case also a considerable part of the early development occurred before the existence of any science of thermodynamics. So far back as 1680 Huygens proposed to use the explosion of small charges of gunpowder in order to obtain motive power, and Papin in 1690 continued his experiments without success. The idea was simple; a small quantity of gunpowder was exploded at the bottom of a large cylindrical vessel filled with air, and the expanding gases expelled the air through lift-valves, so that, after cooling down, a partial vacuum was caused in the vessel. This reduction of pressure was utilised to actuate a piston, but too little power was obtained, as in a paper published in Leipzic in 1688, Papin stated that: "Until now all experiments have been unsuccessful; and after the combustion of the exploded powder there always remains in the cylinder one-fifth of its volume of air." An explosion engine using inflammable vapours was described in an English patent by Robert Street in 1774. Here the explosion of a mixture containing inflammable vapour and air drove the piston directly. Many attempts of this kind were made, and as early as 1817 Professor Farish, in Cambridge, showed an explosion engine in operation on his lecture table. In 1820 also the Rev. W. Cecil, M.A., read a paper before the Cambridge Philosophical Society, in which he described a hydrogen engine, and showed it in action operating by the production of vacuum after explosion. Even the first definite and accurate proposal to compress the charge before explosion was made by William Barnett in 1838, some years before Joule's first paper read to the British Association on the Mechanical Equivalent of Heat.

Internal-combustion engines were thus proposed long before the inventors could have availed themselves of thermodynamics. In these inventions only comparatively simple observations were necessary to produce a working machine. Obviously a gaseous explosion by expansion exerts considerable power, so the early inventors made inflammable mixtures and produced at first explosions starting from atmospheric pressure. They found such explosions weak, and sought to obtain higher pressures and more power by compressing the mixture before ignition. A whole series of inventions sprang from this idea, such as those of Beau de Rochas, Otto, Clerk, Robson, Atkinson, and Diesel. The first commercially successful compression engine was that of Otto in 1876—twenty-eight years after Barnett's proposal. The development of the idea continues to the present day, and now, in 1917, some seventy-nine years after the proposal of compression, we are still inventing and designing new and better internal-combustion

engines, and shall certainly take many years longer without approaching finality. From about 1877 to the present time, however, the science of thermodynamics has been fully applied, and the practical experience of the designer has suggested lines of scientific research into the phenomena of combustion and flame, so that quite a considerable body of abstract science has arisen around these engines which would not have come into existence without the stimulus of a great industry. Many abstract physicists and chemists have contributed to the discoveries made in connection with the working fluid, but the engineers engaged in the design and construction have also thrown great light upon the scientific side. Thus, in the experimental development of the explosion gas engine it was quickly found that the properties of gaseous explosions had not been thoroughly investigated by the abstract investigator. In 1876, when I began work upon the subject as an inventor and designer, I could find no record of experiments made upon the maximum pressures attained by varying mixtures of coal gas and air mixed at atmospheric pressure and ignited by electric spark or flame. The only experiments in existence were those of Bunsen conducted in small glass tubes. Bunsen determined the maximum pressure of the explosion by loading a glass plate valve, closing the end of the tube by lever and weight, like the safety valve of a steam boiler. The maximum pressures so obtained were subject to great errors due to the inertia of the weights and to the very short duration of the maximum pressure in his small glass vessels. Mallard and Le Chatelier made experiments with a better, although still very imperfect, indicator, and with somewhat larger vessels; the records, however, were not sufficiently good to supply the data necessary for studying the explosions within gas engine cylinders. Accordingly I prepared apparatus consisting of a cast-iron cylinder, 7 in. diameter and 7 in. long, of a capacity similar to that of a gas engine compression space, and fitted it with an accurate indicator of the Richards type. By this apparatus I was able to investigate the times and pressures of gaseous explosions under various conditions of mixtures, initial temperature, and pressure. These experiments were published in 1886, and proved most useful to engine inventors and designers. At the same time they brought to light many important facts interesting from the purely scientific standpoint. One discovery was that the rate of explosion in the closed vessel experiments was much slower than that found in the engine cylinder with moving piston for precisely similar mixtures. The complete explanation of the cause of this difference was ultimately found, many years later, simultaneously by Professor Hopkinson, of Cambridge, and myself in the course of different types of investigation, Hopkinson using a fan in a closed vessel and my experiments being made in an engine cylinder with piston actuated and charged in the ordinary action of the engine. The experiments proved the existence of a residual turbulent motion which lasted throughout the whole compression stroke and was due to the velocity of the charge in passing through the inlet valve, which amounted to from seventy to one hundred miles per hour. In my experiments I caused the engine igniter to remain out of operation and held the valves closed, so that the mixture was compressed three times before ignition; this allowed a pause of one second between the beginning of the suction stroke and ignition, instead of one-third of a second, the usual interval in the ordinary running of the engine. The rate of ignition after the rest of one second was about one-third of the normal value, and corresponded closely to the rate of the same mixture in the closed vessel. Hopkinson experimented in a closed vessel fitted with a fan, and he found that the rate of ignition increased with the increased speed of rotation of the fan.

It was also necessary for the study of the indicated thermodynamic efficiency of these engines to learn the instantaneous specific heat of the ignited gaseous mixture which is in a state of flame, the mean temperature of the flame ranging from nearly 2000° C. at the beginning of the stroke to 1000° C. at the moment of the exhaust valve opening. The problem is one of considerable difficulty, as the high temperature only lasts about one one-hundredth of a second, and it is necessary to determine the instantaneous specific heat of the mass of flaming gases at or about one-fiftieth of a second intervals during the expansion stroke. In this I succeeded by subjecting the flame to successive compressions and expansions in the cylinder by the action of the piston, and studying the work area produced by expansion in the short period, and deducing the law of heat loss from successive expansion and compression lines. The results of this investigation were published at the Royal Society in 1906, and at the Institution of Civil Engineers in 1907. This is the

first method discovered of dealing with the properties of flaming gases at intervals so short as one-fiftieth of a second, and I mention it to show how the work of engine invention and design necessarily suggest new lines of investigation not previously dealt with by the abstract investigator. In all the great inventions on which our civilisation depends the process of development has led to the alternate practical trial of the invention and the investigation of the phenomena brought to light by the trials.

Science is thus indebted to industry for its stimulus and progress in many of its achievements, and industry is indebted to science for much information of the fundamental laws necessary for clear thinking in invention and design.

The application of internal combustion in the form of the petrol engine to motor-car and motor vehicle work, and the great recent extension of the use of such engines for the purpose of aeroplanes, has also revealed new problems which for their solution require both abstract discoveries and concrete inventions. The scientific investigation of the conditions of operation, and the invention of better modes of operation, are now proceeding side by side at a rate greatly accelerated by the necessities of war. This is true also of the heavy oil types of engine such as the Diesel as used for marine work.

This alternate action and reaction of invention, design, and scientific discovery is evident in all considerable inventions which always have a long history of development. In attacking the difficulties of the steam engine Watt was well informed of all the science of the day, and the one item of information from a purely scientific source was that of the latent heat of steam, the discovery of Black, of Glasgow University; but Watt found the existing knowledge of the properties of steam insufficient, and part of his work consisted in investigating for himself by actual experiment on saturated steam under different conditions of temperature and pressure. Steam engineers as inventors and designers are now deeply indebted to pure scientific research by distinguished physicists from Regnault to Callendar, but in the early days many of their data had to be obtained by themselves. This applies also to the great modern development of the steam turbine; much of Parsons' work consisted in accurate experiments on the flow of steam through blades of varying configuration, and his great success in obtaining economy superior to the reciprocating engine depended on his investigations of methods of intensifying vacuum by the use of steam-jet ejectors.

This is also true of the development of flight. Ideas were plentiful hundreds of years past: Leonardo da Vinci made many experimental wing models, and attempted what we should now call gliding experiments, but nothing practical came of it till the time of Langley in America. He experimented on large steam-driven models started from a large barge and flown over a lake. He obtained actual flights, but the model fell into the lake and was damaged, so that the experiments were laborious and slow. Definite progress was made by the gliding experiments of Lilienthal and Pilcher, which sadly terminated in the death of both experimenters. Maxim carried the demonstration a stage further, but real flight of heavier-than-air machines was not attained till the petrol engine was developed to a sufficient extent to enable a light engine to be mounted on a glider. This was accomplished by the brothers Wright in America about 1906, and they courageously carried out the early experiments which led to the successful aeroplane of to-day. In this invention also the science of the subject rapidly developed after the demonstration of the practicability. What purely scientific men considered before 1906 as a possible gymnastic feat, under the combined and alternate influence of practical experiment and scientific and mathematical research, has become a reliable fighting and travelling mechanism, whose use can be taught to thousands of young men in the course of a few months' training. In this country the progress of the aeroplane has been due to the combined scientific and experimental work of the Advisory Committee for Aeronautics; the National Physical Laboratory; the Royal Aircraft Factory, and numerous able scientific young men now in the Royal Flying Corps, and private experimenters and designers. Many of these brave men have lost their lives in the development of this wonderful invention; among them we deplore the death of Captain Busk and Captain Lucas, both of Cambridge University, in the pursuit of their duty to their country. Both investigators were brilliant young scientific men, and they accomplished excellent work to keep their names in remembrance. In this development, too, practice and examination of the results have gradually led to the establishment of the scientific facts of the aeroplane, both physical and mathematical.

While on the subject of the contribution of mathematical science to the development of inventions, it is necessary to call attention to the somewhat surprising lack of appreciation

which some very distinguished mathematicians have shown of the conditions of practice and the limitations of mathematical prevision. It is shown in their well-known contempt for experimental physics as compared to mathematical physics. The man of intense mathematical mind feels that until scientific facts can be deduced from first principles originating in the sense of reason in the human mind, the particular science must be stigmatised as "empirical." Mathematical science is not empirical; its conclusions are absolutely true, that we sometimes accept without proper examination of why such reasoning appeals so powerfully. It seems to me that the reason is simple. Mathematical truth is accurate because it is defined so. The deduction, however abstruse, is contained in the definition of certain abstract conditions. Mathematical conditions are carefully defined to begin with, and the investigators discover further relationships which flow from the original definition. Such reasoning supplies the best and highest examples of the deductive method of reasoning, and wonderful and most useful discoveries have been made without appealing to experiment. The discovery of logarithms by Napier was most surprising, considering the condition of other knowledge three hundred years ago, and it is still more surprising if the discovery was really made to enable Napier to accomplish the apparently complicated calculations necessary to arrive at the number of the beast, as is alleged.

This intense introspection seems, however, at times to blind the mathematician to much of experimental interest, and it led its victims into a curious position well stated by Professor Schuster in his valuable book on the progress of physics between 1875 and 1908 as follows:—

"The detachment of the theoretical study of Physics, as it was conducted at Cambridge, from the experimental presentation of facts, led in some cases to a remarkable antagonism to ocular demonstration, which is illustrated by a characteristic incident. Clerk Maxwell, who possessed an innate desire to see what he could with his own eyes, had taken considerable trouble in cutting and grinding a plate out of a doubly refracting crystal to show conical refraction. The experiment is difficult; and, delighted at its successful accomplishment, Maxwell met one of the mathematical teachers of the University. 'Would you like to see conical refraction?' asked Maxwell. 'No,' replied Todhunter, 'I have been teaching it all my life, and I do not want to have all my ideas upset by seeing it.'"

Professor Schuster assures us that this was not jocular; from other statements it appears to have been a characteristic attitude of Todhunter; and some other mathematicians—a well-known professor, for instance—distinctly adopted the same attitude in a slightly different form at a joint meeting of physicists and engineers at the British Association in Sheffield in 1910. He considered at that date that no further flights with aeroplanes should be attempted until the mathematicians had completely deduced the laws of aeroplane stability by discovering the solution of certain equations. He stated that the problem of flight presented separate fields of investigation for those who worked on paper, in the laboratory, and in the air itself. It was important, he thought, that each should concentrate his work in the field for which he was most fitted, and develop it to its ultimate conclusions. There need, therefore, be no serious antagonism between different investigators if each would be content to keep to his own line of work. What he complained of was the misuse of mathematics by engineers, and their slipshod and inaccurate methods of reasoning.

In every advance in engineering, he claimed that mathematical treatment became necessary, and this necessity was recognised abroad. Was it not desirable, therefore, that more facilities should be provided for those working on paper and in the laboratory; and though the ultimate appeal must be to the practical man, he contended that such a course as he proposed would be both cheapest and best. It would be cheapest because mathematicians could be obtained at less price than a mechanic, and it would be best because it would avoid the present frequent deplorable loss of life. So long as anything remained to be studied, those who persisted in flying incurred avoidable risks, and were foolhardy rather than courageous. If experiments would put an end to this working in the dark, they would, he contended, be most conducive to the welfare of the practical man, since it was he who was killed. Had not the practical man already got his hands full with other work? Even as regarded stability, the tests should be made on models, and not with man-carrying machines, and at present there was no need for further demonstrations of the mechanical possibility of flight. Warning should be taken from the history of navigation as described by Elgar, and we should not add further to the terrible death-roll till no stone was left unturned in probing the mathematical theory of stability to the bottom.

This distinguished mathematician obviously shared Todhunter's dislike of engineers' "slipshod and inaccurate methods of reasoning"—that is, of experimental work, and the use of empirical formulæ representing the results of experiments. Mr. Lanchester's work is specially mentioned by him in this connection, and yet Lanchester's alternately experimental and mathematical work from 1897 enabled him to obtain much accurate scientific knowledge. useful equally to the aeroplane designer and suggestive to the abstract mathematician desirous of attacking such problems.

The thinking of the mathematician would be quite sterile if he confined himself to his desk and chair, and endeavoured to evolve the complicated facts of nature out of his own consciousness. Had the Professor's advice been taken in this case the surprising progress of the last ten years would have been impossible. Mathematics without the vivifying stimulus of experiment and practical flight would certainly have failed. As things are, many instructed mathematicians and physicists have co-operated with the practical designer and inventor to produce the existing considerable body of scientific and practical knowledge.

The work of the mathematician is most useful, and it is necessary to success equally in Discovery, Invention, and Design, but it is useless alone—it has never performed, and cannot perform, the marvels of prevision claimed for it by some of its followers.

With regard to chemical discovery and invention, science has followed the same course. Before the existence of any chemical science in the modern sense, mankind for ages conducted many manufacturing processes, such as soap-making, glass-making, iron and copper smelting, sulphuric acid manufacture from green vitriol—hence the old name "oil of vitriol"—brewing and distilling alcohol from many sources, and wine growing and making, dyeing, and so on, all of which involved chemical operations. Alchemy, too, led to many experiments which produced a knowledge of chemical sequences. Thus the earlier chemists of modern type found a mass of information ready for study; their work consisted in studying processes already in existence, and this led to the overthrow of the doctrine of phlogiston by Lavoisier, and the explanation by him of combustion and classification into acids, bases and salts about the middle of the eighteenth century. Lavoisier's work also established the law of the conservation of mass and the law of constant proportions in chemical compounds. His work in chemical theory was so highly esteemed that Wurtz, an eminent French chemist, in a History of Chemistry published about 1870, begins with: "Chemistry is a French science. It was founded by Lavoisier of immortal memory." In one essential matter, however, the true definition of the term "element" as a substance found to be incapable of further analysis, the British scientific man Robert Boyle, preceded Lavoisier, and he has been also described as "the father of chemistry." Boyle also discovered the law of the isothermal compression and expansion of gases.

In 1808 John Dalton introduced the atomic theory, and enunciated the law of multiple proportions without which modern systematic chemistry could not exist. Avogadro's hypothesis, "Equal volumes of gases, simple or compound, contain under the same condition of temperature and pressure the same number of molecules," was introduced in a paper published in 1811, but it was not accepted generally by chemists until explained by Cannizzaro in 1860. About this time the physical properties of bodies were studied as well as chemical reactions and relations, melting points, boiling points, specific gravities, and rotation of the plane of polarisation were determined. In this connection may be mentioned the interesting discovery by Pasteur, made while he was a very young man, that in compounds which rotate the plane of polarisation to the right there exist many compounds of the same chemical compositions which rotate it to the left, such compounds differing only in the arrangement of the atoms composing the molecule in the sense that the reflected image in a glass differs from the object reflected. The law of Dulong and Petit, that the specific heat of elementary solid bodies varies inversely as the atomic weight, proved most important. The original discovery by Sir Humphry Davy of the electrolytic decomposition of the alkalies and alkaline earths producing new metallic bodies was followed later by Faraday's determination of the quantitative laws of electrolysis.

The knowledge of the physical and chemical properties of the elements which had thus accumulated led to the wonderful discovery of Newlands in 1863, followed by that of Mendeleeff in 1869, that the elementary bodies when arranged in order of atomic weight showed a distinct periodicity of properties, so that the elements could be divided into groups of eight of ever-increasing atomic weight with constantly recurring properties. This variation is shown most clearly by Professor Richards in curves of the

properties of thirty-five solid elements. The properties chosen are melting points, co-efficients of expansion, atomic volumes, and compressibilities. So accurate is this periodicity that Mendeleeff predicted the existence of unknown elements because of certain gaps in his tables; and the elements were discovered later, and they possessed the properties proper to their place. The existence of this periodicity suggests a common origin for all the elements, that the elements are in fact built up from some one substance of low atomic weight. This hypothesis was somewhat crudely stated by William Prout, a chemist and physician, at the end of the eighteenth century.

The discovery of radioactivity by Becquerel, and the separation of radium salts by Madame and Professor Curie, supplied Rutherford, Soddy, and Ramsay with the basis for investigations which proved the existence of atoms, or, rather, so-called atoms, which disintegrate spontaneously and form many other bodies. This, with the brilliant work of Sir J. J. Thomson, proved the existence and properties of a unit body called the electron, which body could be detached from any gaseous atom by electric discharge *in vacuo*, and at once suggests that there is some truth in the idea of the ultimate unity of all matter. This hypothesis may yet throw startling light upon the ultimate constitution of matter, the nature of electricity and the nature of mass, and even give a key to the nature of gravitation at present so entirely inexplicable. Sir William Crookes, as early as 1886, discussed the strange periodicity of the elements in connection with a possible unity of origin at a meeting of the British Association.

Chemistry is thus rapidly evolving laws of a most general character, and finding unity in the hitherto bewildering complexity of its sequences.

In this work the progress of spectrum analysis and its application to the sun and stars enables the chemistry of our planet to be applied to other worlds outside of the solar system. Indeed, so interchangeable is general knowledge that the elementary gas, helium, was known spectroscopically as existing in the sun long before it was detected on the earth. Its detection by the late Sir William Ramsay in the mineral clevite, and its subsequent discovery by him as one of the decomposition products of the emanation from radium, forms one of the romances of science.

So far, then, the progress of chemical science displays the same characteristic of abstract investigation leading to the better understanding of existing chemical phenomena and processes by tracing the particular reactions involved and the further work of the discovery of new reactions and decompositions; the effects of mass action, catalysis, electric decompositions and combinations; many of which abstract discoveries have developed into manufacturing processes by inventors and engineers, and so given rise to the great modern electrochemical industry which gives us pure aluminium, copper, and other metals, as also soda and many new products such as calcium carbide and other compounds. Here, too, the history of discovery and invention resembles that of the physical and mechanical discoveries and inventions already discussed.

The marvellous progress in the study of biological problems has been produced by similar action and reaction of abstract investigation suggested generally by practical experience and the testing of hypotheses flowing from the investigation. This is finely shown in a brilliant address recently delivered at the University of Leeds by the distinguished English surgeon, Sir Berkeley Moynihan, where he traces the course of the great modern developments in surgery. The discoveries in antiseptics began, he tells us, with Latour, who established in 1836 the living character of the yeast cells by which fermentation was produced. This was confirmed by Pasteur in 1856, who showed that putrefaction and fermentation were the result of living particles, and that for each type of fermentation a specific particle was necessary. He proved the existence of "aërobic" and "anaërobic" organisms, and showed the error of the old idea that oxygen caused putrefaction. Lister made the forward step that wound discharges were similarly caused, and he applied his deduction to surgery with the success which all know. Moynihan traces the history of many important operations, and clearly shows the interdependence of abstract investigation and surgical practice. He sums up this question very clearly as follows: "A discovery is rarely the work of one mind. It is one observation added to another that makes the supersaturated solution from which the crystal of truth at last precipitates. Lister never ceased to give credit to Pasteur for his share in the work that led finally to the development of the antiseptic method. The exploratory work, the pioneer work—all that was original—was done, therefore, by a French observer and an English surgeon."

Discoverers, like inventors, may investigate

the nature of known facts, facts which have been brought to knowledge by the age-long struggle of mankind to obtain subsistence from an unwilling earth and security of life amidst dangers of nature and man. The discovery may consist in the orderly establishment of some invariable sequence common to a wide class of phenomena; such were the discoveries of the earlier systematic chemists beginning with Lavoisier. The laws of motion, of gravitation, of electricity and electro-chemical action, are all of this type. Or the discovery may bring to light new phenomena never known to man, such as Harvey's circulation of the blood, Jenner's inoculation for smallpox, and the whole series of modern preventive inoculations, the existence of new elements, the discovery of argon by Lord Rayleigh and Ramsay, for example, the new class of substance proving the existence of a disintegrating atom. Or the discovery may be mathematical, such as Napier's logarithms, Newton's fluxions, etc.—discoveries, as I have pointed out, of abstruse consequences of rigid definitions depending on the innate use of reason of the mind.

All these matters are the result of investigation intended only for the purpose of arriving at the truth with regard to the world around us, and, as important, the truth as to ourselves. We are the instrument through which truth and facts appeal, and our reactions require study as careful as that given to the calibration of our apparatus.

Invention, like discovery, begins with a consideration of known facts, but its object is to produce a given result of some specific material utility to mankind; the inventor is also an investigator, but he considers first those facts of science as well as ordinary knowledge which bear on his problem. The inventor's object is to do something required by mankind to aid in the struggle for existence.

Thus, the advent of the industrial revolution in the middle of the eighteenth century began by the use of "sea coal" and the increased production of iron. Coal-pits required to be kept dry, and thus a demand arose for a "fire engine"—that is, a steam engine operated by fire. This was partly satisfied by Newcomen, and James Watt's inventions extended the scope of the steam pump, and ultimately led to steam locomotion on land and water. The inventors' object here was to produce a new machine capable of actuating factories, railways, and ships. The facts required to produce motive power by steam and fire were few and simple, and the conditions of economy were arrived at by Watt without any very elaborate investigation of abstruse phenomena. The work of the engineer and inventor results in the creation of practicable working machines able to perform specific tasks; consequently they press on with all speed on concrete invention, design, and production, without turning aside to understand all the phenomena which appear during their work.

It is their task to produce, not necessarily to understand.

It is the task of the scientific investigator to understand, elucidate, and explain as far as possible the fundamental principles which appear as the result of the operations of the machines now in existence.

Both discoverers and inventors are impelled by the intense desire to produce new things and understand new facts and laws. Neither is actuated by pure commercial instinct; incidentally both, as good citizens of the world, naturally desire a reasonably secure financial position; but the love of money, which is said to be the root of all evil, could not furnish impetus sufficient to maintain either through the vicissitudes of the laborious life necessary to attain the end. To succeed here there must be entire and long-continued devotion to study and experiment inspired by an enthusiastic appreciation of the new possibilities.

Science is succeeding admirably in discovery, and important inventions are evolved slowly by the labours of great numbers of men who may encounter failure after failure through many generations, but yet inventor follows inventor like soldiers in battle until success comes at last. Great inventions are never the work of one man. To adopt Sir Berkeley Moynihan's beautiful simile to invention: "Invention is rarely the work of one mind. It is one observation added to another that makes the supersaturated solution from which the crystal of inventive truth precipitates."

The Chairman (Alan A. Campbell Swinton, F.R.S., M.Inst.C.E., M.I.E.E., M.I.Mech.E.), in proposing a vote of thanks to Sir Dugald Clerk for his very interesting and instructive lecture, said that papers of the kind in question gave one a great deal to think about, as did of course all matters in connection with discovery and invention. He did not know if it had ever occurred to those present why it was that printing took such a long time to come about. The ancient Assyrians used printing of a kind; they had inscribed rolls with which they printed upon clay. That was more than two thousand years ago, and

yet it was not until the middle of the fifteenth or sixteenth century that printing in its modern sense was introduced. The lecturer had pointed out many of the difficulties that impeded the progress of invention, and it had occurred to him that possibly the reason why printing was not in use earlier was because there was no paper. He did not know if that was the true explanation, but of course as long as all writing had to be done upon parchment, and that parchment was very scarce, there was no need for printing, because the small amount of parchment available could easily be covered with writing by hand. It was well known who invented printing, but as far as he was aware, the inventor of paper—which was in many ways a much more complicated invention—was an entirely unknown individual. Again, in many cases invention was impeded by want of proper workmanship. He had recently been reading some letters of James Watt that had only lately been published, and he found that in the year 1784, almost exactly one hundred years before the invention of the turbine by Sir Charles Parsons, James Watt understood perfectly all the requirements for making a steam turbine. He discussed the matter at great length in a letter he wrote to his partner Boulton, but he was prevented from doing anything in the matter by the imperfections of the workmanship that was possible at that time. He wrote: "In short, without God makes it possible for things to move 1,000 ft. per second, it cannot do much harm." By that he meant that a particular steam turbine someone was then proposing could not do much harm in the way of competition with his (Watt's) engine. That was entirely a difficulty of workmanship. The workmen of that time could not make machinery sufficiently accurately to work at high speeds without undue friction. There was not much cause for surprise in that, because James Watt himself, in his earlier engines, had to use cylinders of iron, which were not bored—nobody could bore them—but were beaten into shape, and he thought himself very lucky when the piston fitted the cylinder within one-eighth or one-quarter of an inch. Sir Dugald Clerk had mentioned Faraday, and in that connection he might mention some of the difficulties that Faraday had to contend with. Most of his experiments upon induction were performed with what was called insulated wire. If one wanted some insulated wire nowadays—or, at any rate, before the war—one just went to a shop and bought some; but Faraday could not do that. He had to insulate his wire himself, doing it laboriously with worsted and tape. When one had to make all the essential parts of an apparatus oneself, even down to the wire, it naturally added very greatly to the existing difficulties. He was sure all the members had listened to the lecture with great pleasure, and that they would find it very instructive to read it again carefully. It was not a paper that could be fully appreciated at the first hearing, and he was sure it would repay further study, because there was a great deal of rather subtle information contained in it.

Sir Henry Trueman Wood said it gave him great pleasure to second the resolution, because it afforded him an opportunity of expressing his very keen appreciation of the great compliment the Society had paid him by establishing the "Trueman Wood" course of lectures, and also of thanking his friends, especially the present Chairman of the Council and his immediate predecessor, for all the kind remarks they had made about him. He thought those remarks were the outcome of a sympathetic friendship rather than of keen critical judgment, but they were none the less pleasant to the recipient. He was very glad that the first of the course of lectures had been delivered by Sir Dugald Clerk. Personally he had read a good deal about the history of invention, and sometimes he had written a little on the subject, but he had never come across so lucid an exposition of the essential difference between scientific research and practical invention as that contained in Sir Dugald's lecture. After Sir Dugald had elaborated his hypothesis he went on to demonstrate it by giving two or three most admirable illustrations from the history of invention to prove the truth of what he had said. The whole lecture was founded on a very favourite text of his own—that no man ever invented anything. That was absolutely true, although people did not seem to realise it. In one of the most popular modern histories of England the statement was made that in the year 1767 Watt invented the steam engine, but he never did anything of the sort. Again, in the volume of Reminiscences by one of our most charming and eminent men of letters that had recently been published, it was said that in 1770 Watt patented his engine, but the steam engine was at work fifty years before Watt ever saw one. But for the labours of his predecessors Watt would never have been able to do all the magnificent work that he did carry out. In conclusion, he wished once more to express his personal gratification that the course of lectures had been begun by his old friend, Sir Dugald Clerk, and to say that if Sir Dugald's lecture was followed by similar ones dealing with various branches of the application of science to human progress he really thought his services to the Royal Society of Arts, extending over nearly half a century, had not been altogether useless.

The resolution of thanks was carried unanimously, and the meeting terminated.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

Standard Woollens.—Three or four months may be expected to pass before the new standard woollens for civil wear make their retail *début.*

Their composition and price rather than their external features are standardised, and purchasers will find a range of sound, sensible cloths such as nobody need hesitate to wear. The cost price may be called that of a high-class Saxony tweed before the war, or not much over one-third of the present price of such articles. The quality is not that of good Scotch tweed; but the approximation to old prices and old standards of durability should content reasonable people. Whether we are to have another kind of standard cloth for civil clothing will appear before long. Large quantities are to be made of a worsted serge which might, on occasion arising, be converted to khaki colour or be dyed blue, and which would be appropriate either for military or civil uses. The authorities have ventured upon a standard woollen for men, and an inferior standard for the cheaper clothes demanded for boys; but their discretion has not led them yet to the standardisation of fabrics for women.

Necessary Processes.—A more searching inquisition into the essentiality of particular trades is all too much to be apprehended, and it is already evident that crude judgments will not suffice. It was held the other day by a local body that calico-printing was not in the last resort indispensable, and that women might wear their blouses white. The truth is that calico-printing, like most other trades, is of varying degrees of utility. The process costs little, large bulks are treated in little time, and, in given circumstances, it effects a measurable economy. Printed cottons, having their surface variegated with colour, look fresh longer than white, and save in laundry expenses much more than the printing process costs. Printing is not necessarily an addition to the work of finishing, but is in some part a substitution for alternative processes. Psychological values count also for something in practical affairs, and it can be represented that any rapid and inexpensive treatment which goes to increase personal contentment with one's appearance is worth consideration at most stages of the progress of a war.

Children's Wages.—Advances of wages are made in compensation for the enhanced cost of living, but it is apparent that the excess does not all go in food. An employer of principally girl labour notices that hardly one girl in the mill is without rings on her fingers while at work. Like many others he is exercised in mind about the effect of very high wages upon the young. When a girl of thirteen, a few months out of school, has her 22*s.* wages raised to 24*s.* in consequence of a universal advance, he feels that children are being spoiled with money. Probably enough her father felt himself moderately well paid at no higher rate a few years ago. When children's labour ceases to be cheap, that is one reason for not employing it; but in present circumstances there is no opportunity of getting elder persons to replace them. By the time the over-paid youngsters are grown up there is no knowing what tastes they will expect to satisfy, and the outcome of a possible trade depression is not easy to foresee. A revolution in manufacturing conditions is almost the least that can be anticipated.

Export Business.—Projects for sending out collections of British samples to the foreign markets under care of an association or an official do not command much sympathy from textile manufacturers. They are not reluctant, at the proper time, to book export orders, but are rather more conscious than some of our zealots of the considerations involved in doing remunerative business. A maker of novelty goods finds his passport to favour in the preservation of the element of novelty, and when everyone has seen them their value evaporates. It is by the skilful confinement of his samples to the right channels that the producer is able to get anything for his labours. In the case of plainer goods the opportunity of doing satisfactory business turns upon fine points, which are all the more likely to be perceived after a skilled elucidation. Buyers and sellers appreciate the niceties of trading more fully than they are given credit for, and it is not to be supposed that they are in a position to accept half the advice that is offered them, or all the apparent opportunities of extending their trade.

The Colour Supply.—The British colour-making industry is admittedly not in the position that its best friend would like it to be in, and there is to be a further appeal for capital on behalf of the now great works at Huddersfield. The German combine, having included the sole remaining German independent concern, has raised its capital to £20,000,000. There must, in any event, be an intense commercial conflict to be waged in the dye trade, and the supreme desirability of putting the British works in the strongest position is felt strongly by consumers. Dyers are still without some of their most important staple colours, and they have to make shift with very limited supplies of colours that are nominally available. The position of the dye market is curious. Manufacturers are for the most part only ready to supply consumers under restrictions against resale. Dyes supplied to consumers do, however, filter into the hands of dealers. In one case which has been traced colour delivered at 9*s.* by the maker has resold at 36*s.* The first-named leaves a handsome profit upon the production, and if the second-hand dealings are merely in quantities of ten or twenty pounds, they are still sufficiently lucrative. The German companies, no doubt, aspire to profit handsomely from the temporary famine in dyes.

Historic Logwood.—During the war logwood has come back into use upon an astonishingly large scale—no longer in substitution, of course, for

madder, woad, and cochineal. Three hundred years ago dyers denied the use of logwood, until, the fact having been demonstrated, they set up the defence that its use bettered the dyeing. The dye figured in their books as fustic, and the totals went to show that they consumed every month more fustic than came into the country in a year. Suit was brought against the offenders by an informer, who turned the situation to his benefit by blackmailing the members of the Dyers' Company. The ingenious Hunt drew £4 a year from each member in consideration of delaying action from term to term. The history of crooked practices in the dye trade, it is to be feared, long out-dates the development of the coal-tar industry.

GENERAL NOTES.

South African Industrial Developments.—In his report for 1916, the General Manager of Railways and Harbours in South Africa states that the war has forced the people there to realise the extent of their dependence on oversea supplies. This consideration, coupled with the abnormal shortage of tonnage and the diversion of many European factories to the manufacture of munitions, has compelled South Africans to cater for their own requirements, with the result that many new industries have been established in the Union. Thus, an iron foundry has been started at Queenstown, and brass foundries at Benoni and Brakpan. A smelting plant for dealing with high-grade refractory ores has been established at Barberton. Large works for the manufacture of ammonia have been erected near Vryheid, the principal product at present being sulphate of ammonia. The company operating these works has a sulphuric-acid plant capable of producing 7,500 tons of acid per annum.

Production of Rum in Barbados in 1916.—Four distilleries were engaged during 1916 in the manufacture of rum in Barbados, writes the United States Consul for that island, and the production of rum for the year aggregated 315,359 gallons, against 185,952 gallons in 1915. Of the 1916 total 102,451 proof gallons were exported to other countries, and 1,937 proof gallons were issued for ships' stores, making a total of 104,388 gallon sent out of the island, or 69,851 gallons more than the exports in 1915. The increase in exportation is largely due to the war, practically the whole of this amount having been shipped to the United Kingdom and Canada.

Panama Canal Traffic, 1916-17.—The number of ocean-going vessels using the waterway during the year ended June 30th, 1917, was 1,876, of which 780 were British and 464 United States, the next most important nationality being Norwegian with 150, and then Chile with 99, Peru with 86, the Netherlands with 74, and Japan with 72. In the preceding fiscal year, 1915-16, the Canal was closed by a landslide for a considerable period, and the number of vessels passing through was only 787. The number of ocean-going vessels passing through the Canal in the first twelve months it was opened (August 15th, 1914, to August 14th, 1915) was 1,317.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m. :—

December 12.—Lord Charnwood, "Technical Training for Disabled Soldiers and Sailors." Surgeon-General Sir Alfred Keogh, G.C.B., M.D., F.R.C.P., Director-General of Medical Services, will preside.

December 19.—Professor J. Wemyss Anderson, M.Inst.C.E., M.I.Mech.E., Dean of the Faculty of Engineering and Lecturer in Refrigeration, University of Liverpool, "Science and the Cold Storage Industry." The Hon. Sir Thomas Mackenzie, G.C.M.G., High Commissioner for New Zealand, will preside.

Indian Section.

Thursday afternoon, at 4.30 p.m. :—

December 13.—D. T. Chadwick, I.C.S., "The Trade of India with Russia, France, and Italy." The Right Hon. Lord Islington, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

Cantor Lectures.

Monday afternoons, at 4.30 p.m. :—

H. C. H. Carpenter, M.A., Ph.D., M.Inst. M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology. "Progress in the Metallurgy of Copper." Three Lectures.

Syllabus.

Lecture II.—December 10.—Causes of the decline of the copper-smelting industry in South Wales—Development of mining and smelting in Chili, Spain, and Portugal—Discovery and mining of the native metal in the Lake Superior district—Calumet and Hecla—Opening up of the Australian deposits—Entry of Arizona and Butte into the producing areas—Recent developments in Utah, Tennessee, Queensland, Tanganyika, Nevada, and Siberia.

Chief features of the development of modern copper-smelting practice in America. - Types of ore treated—Mechanically-rabbled roaster furnaces—Great increase in the size and capacity of blast and reverberatory furnaces--Application of Bessemer process to copper mattes—Development of pyritic smelting—Electrolytic refining—Manufacture of sulphuric acid from blast-furnace and roaster-furnace gases—Blast-roasting and sintering of

pines—Leaching—Flotation. Practice at Anaconda—Power production—Concentrator bins—Sampling mill—Gravity concentrator—Flotation concentration—Roasting practice—Reverberatory practice—The blast furnaces.

LECTURE III.—DECEMBER 17.—Converter practice—Refining and casting—Treatment of tailings—Flue-dust treatment—Extraction and purification of white arsenic—Electrolytic refining at the Raritan works—Production of commercial copper. Pyritic smelting at the Tennessee Copper Co.—Hydro metallurgy—Leaching at Chuquicamata—Present-day methods of extraction of native copper at Calumet—Treatment of mixed sulphide and oxide low-grade ores. Tendency of modern metallurgy.

Position of the industry in Great Britain to-day. Importance of copper-refining—Chief commercial varieties of copper, including tough-pitch arsenical copper—Need for exhaustive inquiry into the various aspects of the industry from the standpoint of Empire requirements, and of action to be taken on the basis of the results of the inquiry.

Papers to be read after Christmas :—

LORD LEVERHULME, "The Relations between Capital and Labour—Reasonable Hours, Copartnership, and Efficiency." W. A. APPLETON, C.B.E., Secretary of the General Federation of Trade Unions, will preside.

SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Commercial Intelligence Department, "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

ALEXANDER NEWLANDS, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in the British Isles."

FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." SIR ASTON WEBB, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

WM. FRECHEVILLE, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of Mineral Resources of the Empire." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

ALFRED DICKINSON, M.Inst.C.E., "Water Power in India."

H. M. SURTEES TUCKWELL, M.I.Mech.E., "The Tata Iron and Steel Works" (India).

SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India."

HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-milling Industry of India."

SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912-17, "British Guiana."

C. DU P. CHIAPPINI, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

The following series of papers has also been arranged, dealing with the Application of Scientific Research to the Development of particular British Industries :—

REGINALD S. CLAY, D.Sc., Principal of the Northern Polytechnic Institute, "The British Pianoforte Industry."

GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. LAWRENCE BALL, Sc.D., Manager o Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

SIR WILLIAM GEORGE WATSON, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." SIR ARTHUR D. STEEL-MAITLAND, Bt., M.P., will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

January 17, February 14, March 14, April 18, May 30.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

February 5, March 5, April 30.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced) :—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." Three Lectures.

January 21, 28, February 4. At 8 p.m.

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Economic Condition of the United Kingdom before the War: The Real Cost of the War: and Economic Reconstruction." Three Lectures.

February 18, 25, March 4.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m.:—

P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, "Animal Camouflage." Two Lectures.

January 2 and 9.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DECEMBER 10...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor H. C. H. Carpenter, "Progress in the Metallurgy of Copper." (Lecture II.)

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m.

Geographical Society, Burlington-gardens, W., 8.30 p.m. Colonel H. Swayne, "The Future of Siberia and her Neighbours."

Alpine Club, 23, Savile-row, W., 8.30 p.m. Major Sir F. de Filippi, "The Italian War Zone."

TUESDAY, DECEMBER 11...Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m.

Sociological Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Sidney Webb, "A New View of International Trade."

University of London, University College, Gower-street, W.C., 5 p.m. Professor S. D. Adshead, "Housing Problems after the War." (Lecture VI.)

WEDNESDAY, DECEMBER 12...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Lord Charnwood, "Technical Training for Disabled Soldiers and Sailors."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. A. E. L. Chorlton, "The Agricultural Power Unit: some Factors governing the Design of a Small Tractor."

Biblical Archæology, Society of, 37, Great Russell-street, W.C., 4.30 p.m. Mr. E. J. Pilcher, "The Covenant Ceremony among the Hebrews."

Faraday Society, at the Chemical Society, Burlington House, W., 7.50 p.m. 1. Annual General Meeting. 2. Discussion on the following papers:—(*a*) Dr. J. W. McBain, "Note on the System of Recording Rate of Chemical Reaction"; (*b*) Mr. E. B. Ludlam, "The Effect of Hydrogen Chloride on the Nitrogen-Hydrogen Equilibrium"; (*c*) Dr. E. B. Maxted, "The Influence of Carbon Monoxide on the Velocity of Catalytic Hydrogenation"; (*d*) Mr. A. L. Feild, "The Viscosity of Blast Furnace Slag and its Relation to Iron Metallurgy. A New Method of Measuring Slag Viscosity at High Temperatures"; (*e*) Mr. G. Le Bas, "A Study of the Refractivities of Saturated and Unsaturated Compounds" (Parts I. and II.); (*f*) Dr. A. W. Porter, "The Thermal Properties of Sulphuric Acid and Oleum"; (*g*) Mr. W. R. Bousfield, "On Iso-piestic Solutions."

Colonial Institute, Caxton Hall, Westminster, S.W., 8.30 p.m. Hon. F. M. B. Fisher, "Imperial Trade."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Mr. H. J. Gauvain, "Some Aspects of the Tuberculosis Problem: Treatment and Training of Surgical Tuberculosis Cases."

British Academy, at the Chemical Society, Burlington House, Piccadilly, W., 5 p.m. Professor C. H. Firth, "The Dispersion and Destruction of Historical Records during the War."

THURSDAY, DECEMBER 13...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. D. T. Chadwick, "The Trade of India with Russia, France, and Italy."

Royal Society, Burlington House, W., 4.30 p.m.

British Academy, in the Theatre, Burlington-gardens, W., 5.30 p.m. (Schweich Lectures.) Rev. Professor C. F. Burney, "Israel's Settlement in Canaan: the Biblical Tradition and its Historical Background." (Lecture I.)

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. A. W. Hill, "Seeds with a Stony Endocarp and their Germination." 2. Mrs. R. Haig Thomas, "*Inter se* Experiments in Pheasant Crossing in evidence of Mendel's Law."

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. J. R. H. Weaver, "Architectural Photography."

Optical Society, at the Imperial College of Science South Kensington, S.W., 8 p.m. 1. Mr. J. W. French, "Proposed Standard Optical Notation and Sign Convention." 2. Mr. T. Smith, "Optical Nomenclature and Symbolism."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 5.30 p.m. Messrs. L. B. Atkinson and A. J. Stubbs, "The Metric System."

Historical Society, 22, Russell-square, W.C., 5 p.m. 1. Madame I. Lubimenko, "The Correspondence of the Stuarts with the Romanovs in the first half of the Seventeenth Century." 2. Dr. J. F. Palmer, "Henry of Bray's Plague Recipe."

FRIDAY, DECEMBER 14...Astronomical Society, Burlington House, W., 5 p.m.

Engineers, Junior Institution of, 39, Victoria-street, S.W., 7.30 p.m. Mr. J. G. Moon, "Maintenance of Engineering Plant."

Mechanical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Messrs. A. A. Griffith and G. I. Taylor, "The Use of Soap Films in Solving Torsion Problems."

SATURDAY, DECEMBER 15...Automobile Engineers, Institution of (Scottish Section), Technical College, George-street, Glasgow. Professor A. Mellanby, "The Engineer of the Future."

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Royal Society of Arts

CANTOR LECTURES.

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No. 3,395. VOL. LXVI.

FRIDAY, DECEMBER 14, 1917.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 17th, at 4.30 p.m. (Cantor Lecture.) H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, "Progress in the Metallurgy of Copper." (Lecture III.)

WEDNESDAY, DECEMBER 19th, at 4.30 p.m. (Ordinary Meeting.) PROFESSOR J. WEMYSS ANDERSON, M.Inst.C.E., M.I.Mech.E., Dean of the Faculty of Engineering and Lecturer in Refrigeration, University of Liverpool, "Science and the Cold Storage Industry." The HON. SIR THOMAS MACKENZIE, K.C.M.G., High Commissioner for New Zealand, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

COUNCIL.

At the last meeting of the Council on Monday, the 10th inst., Sir Henry Trueman Wood was elected a member of the Couucil.

INDIAN SECTION COMMITTEE.

A meeting of the Committee of the Indian Section was held on Friday, the 7th inst. Present:—

Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I. (Acting Chairman of the Committee), in the chair; Alan A. Campbell Swinton, F.R.S. (Chairman of the Council), Sir Arundel T. Arundel, K.C.S.I., Thomas Jewell Bennett, C.I.E., Sir M. M. Bhownaggree, K.C.I.E., Sir Valentine Chirol, Sir Frederic W. R. Fryer, K.C.S.I., Sir Henry Ledgard, Colonel Sir Arthur Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., Sir Prabashankar Dalpatram Pattani, K.C.I.E., Sir Frederick Alexander Robertson, LL.D., John Augustus Voelcker, M.A., Ph.D., Colonel Charles Edward Yate, C.S.I., C.M.G., M.P., with G. K. Menzies, M.A. (Secretary of the Society), and S. Digby, C.I.E. (Secretary of the Section).

CANTOR LECTURE.

On Monday afternoon, December 10th, Mr. H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, delivered the second lecture of his course on "Progress in the Metallurgy of Copper."

The lectures will be published in the *Journal* during the Christmas recess.

JUVENILE LECTURES.

A course of two lectures, adapted to a juvenile audience, will be delivered on Wednesday afternoons, January 2nd and 9th, 1918, at 3 p.m., by Mr. P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, on "Animal Camouflage."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 12th, 1917; SURGEON-GENERAL SIR ALFRED KEOGH, G.C.B., M.D., F.R.C.P., Director-General of Medical Services, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Barnett, Samuel, London.

Bewsher, Joseph Ponsonby Horatio, Croydon, Surrey.

Bradley, Major Benjamin, Harpenden.
Carter, Wilfrid George, Kingston-on-Thames.
Connal, Allan Ramsay, A.M.I.E.E., East Sheen.
Copley, J. W., Caterham.
Crewdson, Alfred, Alderley Edge.
Foley, Gerald Henry, R.F.C., London.
Gourlay, C. G., London.
Haslam, William Gilbert, J.P., Derby.
Haynes, Ernest, London.
Lyddon, George Edward, A.M.I.Mech.E., London.
Matthey, George Cowper Hugh, London.
Murphy, William Bernard, Peterborough.
Rawlinson, H. W., London.
Smith, Henry White, Bristol.
Smith, John Sugden, Bradford.
Stewart, Samuel, London.
Thornton, John Edward, London.
Walsh, Frank Ford Peregrine, F.R.G.S., London.

The following candidates were balloted for and duly elected Fellows of the Society :—

Birnie, Cyril Montague, Japan.
Boyd, John St. Clair (jun.), Belfast.
Campbell, James, Saltburn-by-the-Sea.
Hirst, Stuart A., Leeds.
Humphrey, George Harold, London.
Kaye, Harry, M.Inst.Met., London.
Pitman, Archibald R. C., W.S., Edinburgh.
Roe, Humphrey Verdon, Manchester.
Voight, Howard Edward Latimer, Stanmore, Middlesex.
Warner, Frank Cloudsley ff., London.
Wiblin, Frederick Avent, Plymouth.

The paper read was—

TECHNICAL TRAINING FOR DISABLED SOLDIERS AND SAILORS.

By Lord Charnwood.

I accepted eagerly the invitation to address you, because, though my knowledge is neither so complete nor so practical as to make my paper strictly worthy of this Society, there are certain simple outlines of my subject which I would like to impress on as many Englishmen of influence in diverse spheres as I can.

My subject is the training of disabled men when necessary. I need hardly refer to their pensions. I shall refer to their curative treatment only so far as that is necessarily associated with their training.

I do not need to tell you, or any British audience, what a debt we owe to our disabled sailors and soldiers, nor that this debt cannot be liquidated in money, but includes the wise and active doing of all that we can to help those among them (the vast majority) whose disablement is only partial to their due place in civil life, so that after the war the average maimed man shall be not less of a man, but, as he well may be, more. You are well aware of the tragic aspect of the problem, and I shall at least make you sensible of its difficulty: let me, before I plunge into long and dry explanations, simply ask you to remember the element of high hope which it involves. I would have you regard it as the first stage in that work of reconstruction after the war which indeed gives many causes of anxiety, but which ought not to be approached without a sense of its vast possibilities of good. Far be it from me to make little of the individual suffering and social harm which will arise if any large number of the cripples and invalids of the war go without the help which is their due; yet I had rather turn your chief attention to this, that among this mass of damaged men there are cases, exceptional no doubt but very numerous, of latent capacity and character, and an unprecedented opportunity now arises of discovering, developing, and directing this capacity and character to the great enrichment of the life of the community.

First, I will try to give you some idea of the size of the problem. We have no right to regard it as unmanageable from its mere magnitude. Up to the end of September 1917 the total number of officers and men discharged from the Navy and Army as unfit for further service was about 225,000—less, I think, than most of us imagined, for we hardly realise how many of the inmates of military hospitals recover completely—and here is a table showing roughly how any average thousand of these disabled men are distributed in respect of the kind of disability from which they suffer :—

Number of Cases in every 1,000 Disabled Men (excluding Officers) so far discharged from Army or Navy during the War.

Cause of Disablement.

Injury to eyes (including an occasional case of total blindness)	32
Amputation of leg	30
Amputation of arm	19
Injury to leg not requiring amputation . .	121
Injury to arm not requiring amputation . .	82
Injury to hand not requiring amputation of whole hand	61
Injury to head (including, say, six or seven paraplegic cases)	47
Hernia	7
Miscellaneous wounds and injuries (including, say, about five paraplegic cases)	54
Total wounds and injuries . . .	453

Diseases of chest (including, say, 60 tubercular cases)	124
Rheumatism	50
Diseases of heart	110
Epilepsy	11
Nervous cases	47
Insanity	9
Deafness (partial, or, in comparatively rare cases, total)	26
Frostbite (including cases of amputation, which are less than one-tenth of the whole)	10
Miscellaneous diseases (among which may be noted, besides a few paraplegic cases, Bright's disease, ulcer of stomach, debility, and varicose veins)	160
Total cases of disease	547
Total wounds and injuries	453
	1,000

I must point out that the proportion of cases of amputated limbs will, at the end of the war, stand somewhat higher, because such cases remain in hospital longer and are discharged from the Services later, and also that a class such as "miscellaneous wounds" or "miscellaneous injuries" includes a certain number of very sad cases indeed. Yet I think we may draw at once two conclusions from this table—the one by way of encouragement, the other by way of warning. The number of palpably grievous injuries is, and, however long the war lasts, will be, well within the compass of the community to deal with as they should be dealt with. On the other hand, there is in our midst a constantly growing number of men more or less enfeebled by injuries of very various kinds and uncertain extent, some of whom will certainly get better, some of whom will get unexpectedly worse. Every neighbourhood in this country, acting with the guidance which central authority can give, has now to grope its way through a problem such as no community has set before itself in any former war—that of finding out how many and which of these men need special help, and how that help can be given. Before leaving this table I must make one further remark in relation to our particular subject to-day. A grievously injured man, say one who has lost his leg, is grievously injured, but it by no means follows that he is specially disabled for his own special trade and needs to be re-educated for another. A tailor or a novelist, who has lost both legs, is a subject for sympathy but not for re-education; on the other hand, a man with a pulmonary trouble, which would impede you or me very little, may have undergone this disaster that his accustomed way of life is precisely that which will make his disorder serious.

Next, you may wish to be briefly reminded of the administrative system, which has now taken its final form for dealing with the disabled. Up to a certain point the naval or military authorities are responsible for the care of these men in their own hospitals. The primary function of these hospitals is, of course, to return men healed and well to the Services. For those who cannot be thus restored, these authorities undertake the responsibility of caring for them in naval or military hospitals just so long as the treatment which those hospitals can supply is on the whole good for the man himself. When that point is passed the man becomes the charge of the Local War Pensions Committee of the county or county borough to which he goes home as a civilian. That Committee is responsible in the first place for his receiving the pension due to him; it is also charged with the payments due to the widows and fatherless, and this business of pensions constitutes, of course, the bulk of its work. It is, however, responsible, in the second place, for making available to him—as a patient to an ordinary doctor, an outpatient in a hospital or special clinic, or an inmate of one of the special institutions for special cases which are being created no faster than they are needed, and yet with very admirable speed—the further medical care which he may require. It is responsible, thirdly, for discovering the need which he may be under of new technical or professional training, and discovering how to supply that need. For this last purpose neighbouring Local Committees can associate themselves together so as to organise technical training for whole large districts of the country. The Local Committees are constituted somewhat differently according to the character of their neighbourhood, but in general include the representatives of every class and every interest concerned. They do their work with the help of sub-committees in different parts of their localities. This local organisation is controlled, guided, and I think we may fairly say inspired, by the Ministry of Pensions, which has now absorbed the powers and duties of the older Statutory Committee; and this Ministry stands in relations of intimate correspondence, in regard to different aspects of its task, with the Admiralty and War Office, who control the hospitals; the Red Cross, who are the pioneers in creating new institutions; the Ministry of Labour; the Ministry of Munitions, which is the employer directly and

indirectly of so much labour; the Board of Education; the Board of Agriculture, and other central authorities. It has a huge task and a new task. It has taken new premises; they are already too small. As a consequence its staff, though large, is also too small; and, as a further consequence, it can claim a little indulgence if its response to an inquiry is sometimes slow. On the whole, we may rest satisfied that our organisation, as an organisation, leaves little to be desired, nor, so far as central authorities are concerned, need we trouble ourselves as to any lack either of capacity or of sympathy on the part of the Ministers concerned or of their staffs.

Now observe the policy adopted in regard to training. If a discharged man desires to be trained for a new occupation, if it appears that he can wisely enter that occupation, and if, through the agency of any technical institution previously existing or created for this purpose, or through that of any private employer, adequate training can be provided for him, Government will pay any necessary fees. It will pay the man during training from 27*s.* 6*d.* a week upwards according to his former Navy or Army rank; it will pay, if he has to leave home, separation allowance which, for example, would bring the income of a man with a wife and three children up to a minimum of £2 13*s.* 9*d.*; it will continue these payments so long as the necessary training lasts; and at the end it will pay the man a lump sum of 5*s.* for every week of training that he has gone through. And there is no limit to the time for which these payments may be continued except the period which expert opinion fixes as sufficient for teaching the trade concerned. This is a large and liberal undertaking. It might be expected to be a slow and difficult task to supply the training required. So it is; but, speaking of the great mass of working-men discharged from the Army who first engage our attention, the real discouragement lies in the fact that very few wish to be trained. If you visit certain great institutions of training you will see a wonderful work going on; but if you call on the Pension Committees of two or three great industrial counties and inquire as to the progress of training, they are pretty certain to say that they have come across very few men who want training or will even accept it when the advantage in their particular case is pressed upon them.

This is no peculiarity of our own country or our own people. Save in the peculiar case of the Belgian disabled, who, having neither trade nor home nor country to go to, are necessarily inmates of one vast institution, it is the same so far as we know in all the belligerent countries. And, I think, the dream of avoiding this foreseen difficulty by some exercise of Army discipline, extended over the soldier long after he had ceased to be a soldier, and fitting him willy-nilly into the new niche in civil life that might be thought best for him, was never anything but a dream. The disabled man may be a complete and permanent wreck, who needs must go to the place of refuge provided; or he may be blind and little inducement is required to take him to that wonderful place of education which the devotion and organising genius of another blind man has built up for him; or he may be, say, a professional pianist with both hands amputated or crippled, who must obviously seek any other form of skill that can be imparted to him. But the vast majority are under no such overwhelming disability; they want to be back at their old home, near their relations and their wife's relations, to sing in the choir of the old church or chapel, to drink in the snug of the old public-house, to be employed about the old works, or to take such advantage as they still can of the high wages now going in the old town. And this they can do. For the very much broken man the old employer can find a light job quite easily; he has lost his right arm, for example, but the employer has a lift which he can work with his left arm. If light jobs in the old shop do not suffice, the demand for men is, as we know, huge, and the demand for half men (even for half-intelligent, uncrippled men, much more for intelligent half-crippled men) is great. What is therefore happening is natural, it is even healthy, nor is it from our point of view this afternoon altogether a misfortune. There is yet a breathing space during which those on whom the responsibility lies, feeling their way as quickly as they can by constantly increasing experience and example, can perfect the means of meeting the need which will come. But the need will come. To a great extent our disabled men, induced by money wages which four years ago would have seemed very high, are remaining unskilled if they were unskilled before, or are even educating themselves down from the skilled to the unskilled ranks. The war will end—eventually, and sooner or later after it the contraction of industry will come; the employer's requirements will alter, his embarrassments will spring up, his business will change hands, or he will fail; some millions of

undisabled and unpensioned soldiers will be then wanting work.

The heavy weight of depression in industry will fall, as always, most heavily on those unskilled ranks in which so many of our soldiers (less frequently our sailors) will have enrolled themselves. That is the great impending evil. But there is, I believe, another already making itself felt. A recovering patient often underrates his recovery; more often, after a while, he over-rates it very much. I give you the impression of at least one able Local Committee, that a large proportion of the men under their charge are going back in health, because they are doing work that is too heavy for them. All this gives us a threatening prospect. By the way, it has its cheerful side. It reflects the average perversity of the working-man, who, on the average, is quite as perverse as other kinds of man; but it does not reflect any prevailing lack of healthy social instincts or of manly energy.

I pass to a brief sketch of the chief schemes now in operation, or well advanced in preparation, for supplying this great need. If what is being done should seem inadequate (fully adequate it can hardly be), I will ask you to remember that in every department of life the country is short-handed, and that those of us who are available for new work are *primâ facie* incompetent for any. I prefer to give you a dull catalogue, which includes a fair number of examples, rather than repeat the fascinating details of any one of these beneficent enterprises. I greatly regret that my friend Major Mitchell, the Director of Training under the Ministry of Pensions, is not in my place at this moment to give account of himself.

I have no concern here with those broken men, never to be forgotten, whose sojourn in institutions such as the Star and Garter (which once enjoyed so different a notoriety) is but the preliminary to a longer rest. Nor ought I properly to refer to those surprising forms of apparently feminine fancy work which afford solace in many hospitals to strong men on their backs; for these belong to recreation, which is an adjunct of cure, and not at all to training; but I would like to advertise that the organising of this form of hospital comfort is a very true work of charity.

I start with an institution, which must be mentioned first because it has led the way in work for the disabled. I mean the Lord Roberts' Memorial Workshops. The fact that these workshops aim at employing the men whom they train, indicates sufficiently the limitation upon their scope. But at the same time it enables them to deal in the best way with cases for which no other agency can so adequately provide; for they are able to set up machinery specially devised for use by disabled men, and in this way to make industrially efficient some who could never have been so under any ordinary employer.

I take next the *blind*. These stand rather apart from the other disabled, because they will so manifestly need a certain supervision and occasional help all their lives. But they are relatively few, and, as you know, the art of helping them has grown to great perfection, and generally their power of recuperation—after a period of dark anguish—is amazing. It is not surprising to learn that there is a considerable field of work for blind men as masseurs, but it marks the length to which skilled instruction can go that an appreciable number of the men at St. Dunstan's in Regent's Park are successfully trained for poultry farming.

Contrast the *deaf*, whom I mention, because, while a blind man attracts sympathy, a deaf, or at least a partially deaf man, is apt merely to irritate us—I will say, if you prefer it, to irritate me. They lie on the fringe of my subject, for the cases of total deafness resulting from the war are so few, and the openings appropriate to them so miscellaneous, that they are hardly subjects for any large general scheme, and should easily be dealt with locally. But partial deafness caused or aggravated by the war is common. It is not a special disqualification for any trade, but it is an impediment in all, except perhaps that of political debate. What I want here to advertise is: first, that partial deafness can very often be greatly alleviated, and that local clinics are now being started for this purpose; secondly, that employers in factories are sometimes afraid of the extra risk of accident to which the deaf are exposed, that the risk is, I believe, exaggerated, and that the partially deaf man can more than counterbalance it by becoming a teetotaller; thirdly, in regard to the quite deaf, that kind people who are likely to meet them can learn, say in an hour, the finger language—I hope I may find that hour and use it myself.

To come now to what I may call the central part of my subject, *cases where a limb has been lost*. Observe that the loss of an arm is generally a far worse handicap than the loss of a leg—happily it is a good deal less common. The degree to which a man can make good such a

grievous loss no doubt varies a good deal with his manhood and general capacity. There is a Berkshire farm labourer at Roehampton who has lost his right arm below the elbow; he is now instructor in poultry keeping and other matters there, and you will not easily find a more efficient farm hand—he is not very young either. In the physics laboratory at Eton one may meet a former gunsmith, who also has lost his right hand; he has charge of and does ordinary repairs to the delicate electrical and other apparatus there, and with his hook and his left hand he can tie knots in a fine silk thread. I have a nephew who, before the war, played conjuring tricks: he had two arms then; he has lost his right arm too completely for any artificial appliance to be fitted on. He still plays conjuring tricks, which personally I could not do with four hands (he has, I should add, a more useful occupation for most of his time, in fact he is now again at the front). Now I do not suppose that the moral courage which such men show is altogether lacking in many of their fellows. I hazard a guess that the loss of a limb would have been to most of us at, say, thirty, a challenge which we should have been inclined to take up. Depend upon it there are limbless men who will do far more than make up for their handicap. But remember that they have first to recover from a tremendous physical shock—not at all as if fairies had gently removed a limb from them in the night. Therefore, if you should be led to visit, say, the Pavilion Hospital at Brighton, where men remain convalescent after operations while their stumps get ready for artificial appliances, or the now famous hospital at Roehampton, which is the first of those centres where they are fitted with such appliances and begin to learn to use them, it would not be wise to approach them with the demand that every man should be practising some new trade or his old trade. Nevertheless, as you probably all know, a surprising number of them, at these and similar institutions, are not only learning new trades as joiners, engineers, electricians, or commercial clerks, but have gone very far indeed in the process. The Exhibition generously organised last summer by Messrs. Sotheby, Wilkinson and Hodge, and to be repeated on a larger scale next year, contained examples of their work which any man would beforehand have called incredible.

Hardly less startling is the work in orthopædic hospitals, such as that at Shepherd's Bush. "Orthopædic" means training a child straight, and has etymologically nothing to do with "pedal" or "pedometer," and Sir Robert Jones and the like of him, including sixty American surgeons who, characteristically, formed the advanced guard of their European army, are occupied in restoring the right use of limbs and joints crippled for the time by any cause, such as the severance of an important nerve. So efficiently do they do this that at least ten in fourteen of their patients go back in some capacity to the Army, and about one in six of the total patients as "A" men. Thus all that they do in these hospitals must be looked at primarily as treatment, not training, and it is supremely important that it should be so looked at. Men making cigarettes there, under tuition supplied by Messrs. Abdulla & Co., are not doing so with any view to a desirable trade opening, but because this occupation, which enlists their interest and their will, is the best thing to restore the lost flexibility of their fingers. For just the same reason other men are swabbing the dirty windows or the like, while a large number of workers in wood, in metal, and in leather—most of them, but not all, belonging previously to these trades—are making the splints and other appliances required by their own and other hospitals. By the way, I would like you to observe that in military hospitals and military convalescent camps neither play nor work of this description is done under any sort of compulsion. It is curative, yet the training is a fact, and the result is that the four in fourteen or thereabouts who will be invalided out of the Army or the Navy go out with their capacity for their old employment largely restored, perhaps enhanced, and a certain number go out having acquired a new trade. Now I will ask you to remember that a good many men are discharged from these hospitals and from others who would benefit greatly by a continuance of orthopædic treatment as out-patients, or who in some cases relapse and would do well to return to such hospitals. Notice, therefore, in the neighbourhoods where you have influence, the progress in the creation of new centres for this largely novel orthopædic treatment, a progress limited, I ought to say, by the comparative fewness of practitioners trained in this particular skill. Watch, if you will be so good, the efforts in your own districts to create orthopædic annexes to general hospitals for the benefit of discharged men, and the development, now projected and destined, I hope, to steady progress, of industrial classes in the technical schools of the same towns, which, working as they will in conjunction with the curative pro-

cesses of the hospitals, are likely to be important agencies in the re-education which we are considering.

In the special institutions for nerve patients discharged from the Army, and in a rather surprising number of cases from the Navy, we learn, as we might expect, that occupation plays at least as large a part in cure as in orthopædic hospitals. It must be a light and attractive occupation, but, apart from that, its character probably makes little difference to its curative value; and for this reason, and since these are men who have done with the Service, the patient's future bread-winning needs can be freely considered. One most interesting experiment in re-education is the training given to nerve patients at Golder's Green in the intensive culture of vegetables under frames and glass bells. Similarly, the chief institutions formed for epileptics are farm colonies.

I must point out that what I have said of Roehampton applies also to the other centres for cases of amputated limbs, of which Erskine Hospital near Glasgow is, perhaps, the best known, and what I have said of Shepherd's Bush applies also to other orthopædic hospitals. I think I have now said all that is necessary of the part that is, or can be, played by hospitals or similar institutions in imparting technical instruction or laying the foundations for it. In so doing I have passed in review the chief of those special disabilities to which a marked and obvious need for new industrial training generally attaches.

But the training given, for example, at Roehampton is, of course, in most cases only a beginning; it has to be carried further in technical schools or in factories or workshops where the employer is willing, as very many employers are, to organise instruction. And besides, there is that large number of miscellaneous invalids of war, of whom I have spoken, and whose varied needs have to be discovered and supplied. You will understand that I cannot give you any complete list of the classes that have been approved by the Ministry of Pensions and are now being carried on in technical schools in many parts of the country; much less can I tell you of the number of instances in which an individual disabled man is learning under an individual employer. I give some examples which show that good work is being done, and which suggest that similar work can be done also elsewhere.

The London Polytechnic in Regent Street has from the first been working in close association with Roehampton, from which most of the 138 disabled men, who are at this moment being trained in it, have come. The courses provided for them include fitting, metal-turning, electrical work, architectural drawing, commercial subjects, tailoring, cinema operating. Their instructors can point to 270 old pupils, all seriously disabled and all now earning good wages.

The Borough Polytechnic has classes in dental mechanics and in baking.

The Battersea Polytechnic has seventy-five men training to be motor mechanics, chemists, electrical workers, or (in the case of a few picked men) sanitary inspectors.

The Northampton Institute in Clerkenwell is training twenty men at telephonic switch-board work.

The Cordwainers' Institute in Bethnal Green Road trains seventy-nine men in boot and shoe making and general leather work.

The course for boot and shoe makers, I should mention, is very thorough; it lasts forty-six weeks. There are, however, repairers who are trained only for six months.

Clark's College in Chancery Lane teaches commercial subjects to seventy-nine disabled men.

Before I pass from London institutions, I wish to pay my tribute to the Eccentric Club, a body, I believe, of gentlemen belonging to the stage. They have illustrated their name by an original and most beneficent work, the foundation of several hostels to afford fitting board and lodging and social advantages to disabled pupils of several London institutions whose own homes are far off. Outside London it would be invidious, and in some cases unjust, to mention the chief towns whose technical schools are or are not being used in like manner. But you must not suppose that the only bright examples are in London, and I think I may mention the Joseph and Jane Cowen Training School at Benwell Grange, Newcastle, a residential college for the training of disabled men in various trades—a pioneer institution of its kind.

Among the notable services by employers stand the training given by Messrs. R. H. Davis and Co., in fancy leather work to a number of disabled men, most of whom remain in their employment, while some of the most proficient go to be instructors to classes that are being set up elsewhere; and the interesting enterprise of Mr. Bernard Oppenheimer. This latter is an endeavour to transfer the diamond-cutting industry to a portion (namely Brighton)

of that British Empire within which most of the raw material is found. Provision is made by Mr. Oppenheimer for the training of 1,500 men.

The Aircraft Federation, I learn, have now formulated schemes which should provide training and employment for at least 5,000 men.

The Munitions Department is active in this matter. Nearly all the (not very numerous) disabled men from one large and very soldierly county that I know, are trained in this department's classes at the Loughborough Technical School.

The Scottish Board of Agriculture is devising, in concert with large landowners, training and employment in forestry.

The English Board of Agriculture has got to work, I do not say too soon, not only on training in forestry, but on training also in horticulture, and in the working of motor tractors. For the pupils in this last occupation, employment can, I understand, be officially guaranteed.

So, you see, the movement does go on, and you must recall that no similar movement has ever gone on in the world before, and looking both to the difficulties of organisation and to the slowness of demand on the part of the men themselves, you will not wonder that the largest of the schemes which I have mentioned are of recent origin. Meanwhile, the further progress of the work is being prepared for by a careful reconnaissance. Committees of employers and employed in a number of the chief branches of industry have been set up by the Ministry of Labour, and have issued, or are preparing general reports on the scope for employment in different trades, and the training that is appropriate. They are producing also a numerous progeny of local sub-committees which will study these matters more in detail, and will overcome, it may be hoped, those difficulties in relation to existing employees which might otherwise cause impediment. The reports already issued may be procured by any one from the Ministry of Pensions.

So far, there is nothing but what is satisfactory to tell about the finding of employment for men that have been trained. But it is not surprising to learn that disabled men have been apt to take a fancy for one or another employment of a kind that is likely to have too many men in it. The occupations of a chauffeur, and of an ordinary not very highly skilled clerk are the chief examples, and these and several others have been black-listed as *primâ facie* unsuitable trades to which to train a man.

I am afraid it does not surprise me to find that the movement for establishing small-holdings for soldiers, invalided or otherwise, of which we once heard much, goes slowly. I hope, not that it will continue to be slow, but that it will continue to be cautious. Agriculture is not the least skilled of occupations, as some seem to think, but the most skilled. Small-holding requires the right soil, the right neighbourhood, the right small-holder. It requires also some capital. Above all, it is a way of life in which a man stakes much on the continuance of his own full strength till he has strong sons to help him. These things are not said by way of crabbing, but of warning, and the warning is meant to apply to the particular idea of small-holdings, not to the wider and most sound persuasion that there is immense scope for the training and employment of skill in relation to agriculture.

You will, I should like to think, ask, What about professional as opposed to mechanical training? Is there not, for example, such an occupation as that of the schoolmaster, in which men will be increasingly needed, in which character and knowledge of human beings count for more than technical method, and in which the man who has fought for his country is, other things being nearly equal, the better man? What is being done in this direction? I hope you will continue to ask these questions loudly and publicly, not with a view to awakening Mr. Fisher, who is awake, but with a view to supporting him. I hope, too, that you will want to know about our disabled officers. Nothing can surpass in its way the beauty of the surroundings in which some of them lie, except the boredom that broods over them. The openings that can be imagined for a good many officers knocked out of their previous work, are very many, and so are the studies, especially in certain modern languages, which would be very useful to many of them, and useless to hardly any. Moreover, the difficulty of combining the purpose of teaching with the primary purpose of a hospital, is not, I submit, so great as it is in the case of a private soldier, whom it would be cruel, as well as mischievous, to set thinking of a new civil job, when his first business is to get well and fight again.

But—for it is high time now that I concluded with some sort of a moral—in this and in all other matters of which I have spoken, it is not the Government, but the public and ourselves that we need to stir. If knowledge and interest on this whole subject be diffused, voluntary initiative in many quarters will set more things

going than in our general survey we can foresee. Upon the whole, we cannot hesitate to say that in this great field Government serves us well.

Returning then to the larger aspects of the subject, I have chiefly this to say: First, it is still more among the men themselves than in what are called influential circles that knowledge and interest need to be aroused. Let them understand more generally both the dangers and the opportunities before them, and if greater opportunities be needed let the demand arise chiefly among them. There is progress in this matter already. I am told that the false idea once prevalent here and in France, that a man would lose in his pension by becoming skilled, is disappearing, and besides, many men who have eagerly taken up well-paid blind-alley work, or work for which they were physically unfit, must be beginning to reflect about it. Everyone who visits hospitals, and everyone connected with large works, should interest himself or herself in this. There need be no intrusion, no offering of advice which offered to ourselves would seem impertinent. General talk on what is being done, and what needs to be done, will set the man himself inquiring. Above all, it is working-men and working-men's leaders who can talk straightest and most shrewdly—as Mr. Gosling, for example, has talked—to the soldier who must go back to the workshop. Secondly, next to the men themselves, an appeal must be made not to important quarters in London, but to the local public opinion which influences local authorities and stimulates local leaders. Generally speaking, local administration is as sound and sensible in this matter as in most others that relate to the war. But local war pensions committees are burdened with much pressing work as to pensions, and in this matter, may I repeat, all that is being done is of the nature of a new invention, and new inventions need advertising. There are localities, too, where the whole war pensions business is being run on routine lines as one of the many odd jobs which town clerks and their offices have to take on now, when a special officer is really wanted for the work. And there are localities, far more numerous, where between the good employment which prevails for the moment among the discharged, and the difficulty of devising what is wanted in the way of training, the idea of training has naturally enough lapsed. And as for the keen local authorities, I do not suppose there is one which is not hard worked or (except in favoured neighbourhoods) which does not feel the need of volunteer helpers who will take to such work and stick to it.

Well, I know I have not given you all the information you desired, but I am vain enough to hope that perhaps I have stirred in you precisely that blend of dissatisfaction and of hope which this great and pregnant topic demands.

DISCUSSION.

The Chairman (Sir Alfred Keogh), in opening the discussion, said he had been interested in the subject with which the paper dealt ever since the beginning of the war. The author had called attention to the fact that no similar movement had ever taken place in the world before, and that was literally true, although such movements on a smaller scale had often been required before. He could remember many campaigns in which the care of the maimed and those afflicted in other ways than the maiming of their bodies had been entirely neglected; in fact, in this country it had been the rule simply to pay the discharged soldier his pension and let him look after himself. In the case of the present war it was the magnitude of the work to be done in the direction to which the author had alluded that was of importance. That importance would continue to increase and would be very evident to the public when demobilisation took place, although it might not be so obvious at the present moment. In his opinion, with the exception of the war itself, which of course came first, nothing was of greater importance than the diffusion of knowledge upon the subject, and the success of the undertaking depended upon that knowledge being diffused in good time. The author had dealt almost entirely with the training of the soldier, but the question of the treatment of the soldier was of equal importance. The military hospitals were doing as much as they could in the matter of the treatment of the soldier, but when peace was proclaimed men who had been soldiers, and whose engagements in the Army were terminated, would have a right to return to civil life. There would not be—and there ought not to be—any power to retain them in the hospitals; therefore many of those men would come out of the hospitals without being fully cured, and would be handed over to the Government to be cared for after their discharge. It required little imagination to realise that that was going to be a tremendous problem. The author had stated in his paper that the Government was doing successfully all that a Government ought to do in the matter, and he could very warmly echo that opinion. A great deal of all that had been done with regard to the treatment of the serving soldier within the last three years, in the various hospitals and other institutions, could not have been accomplished without the aid of the civil population, who had rendered invaluable volun-

tary service; but he thought the great question of the treatment and training of the discharged soldier should receive an equal amount of attention from the general public. He wished to see committees and voluntary organisations springing up in every town and village in the country for the specific purpose of looking after the discharged soldier, just as similar voluntary organisations had been formed for the benefit of the serving soldier. The former work might not be so romantic as the latter, but he ventured to say it was infinitely more important. The authorities who were responsible for the work were doing all they could to make it a complete success, but he did not think that success could be achieved without the aid of the general public. He hoped the author's words would reach from one end of the country to the other, as they dealt with a subject of tremendous importance, socially and economically. Those wen who were permanently disabled in fighting the battles of their country, were entitled to that country's gratitude.

THE SECRETARY read the following letter from the Right Hon. Sir Frederick Milner, Bt.:—

December 11th, 1917.

DEAR MR. MENZIES,

I had hoped to be able to be present at Lord Charnwood's paper to-morrow, but the time is an awkward one for me, and I fear it will not be possible. My deafness would have prevented my hearing much of what went on.

Had I been present, I should have liked to say that, as far as London went, the technical training for soldiers and sailors is very satisfactory, and the work of the Eccentric Club hostels is most valuable in housing the men who are learning.

I fear things are not so satisfactory in the provinces, and it seems to me that Local Pension Committees have very little knowledge of their duties, and their powers in this direction. In many places nothing at all is being done in this direction. In others, where an attempt has been made to train men, complaint has been made that they get very little assistance or advice from headquarters. One crippled man in the Pontefract district was very anxious to learn boot-making, but he said he had been waiting week after week, and nothing was done.

I have had complaints from men from all over the country, saying they could get no facilities whatever for learning a trade. At York, which is a large military centre, I find that so far only five men have been given the opportunity of learning trades.

I hope it may be possible to take steps to acquaint local authorities of their duties in this direction, and of their powers.

I do not know if it will be possible to read this letter at your meeting, but I think it is a subject worthy of discussion, and I should like to know the views of Lord Charnwood and others about it.

Very sincerely yours,

(Signed) FRED. MILNER.

P.S.—I may mention that our Roberts' Memorial Workshops are a very valuable means of employment for crippled men, and our numbers are daily growing. We are always glad to take in cases that are brought to our notice. We train the men ourselves.

MAJOR ROBERT MITCHELL (Director of Training under the Ministry of Pensions), said that in answer to Sir Frederick Milner's criticism, he thought it only fair to say that there were reasons why in many large industrial centres more had not been done. It was the desire of the Ministry of Pensions that the training in question should be of such a character that the men when trained would not be like black sheep amongst their fellow-workers, but would be welcomed and treated as part of themselves. Special arrangements had therefore to be made, which had taken a long time to develop because there were so many interests to consider. Special Training Advisory Boards, consisting of representatives of the leading Trade Unions and Masters' Associations, had met at the Ministry of Labour and considered all the difficulties with regard to the matter, with the result that there were now eleven declared trades with all the special arrangements made whereby discharged soldiers might receive their training. The conditions under which the men would receive their training, the length of such training, and the rate of wages they would receive, had all been settled, which was a result worth waiting for, because the men would become respectable and independent members of their trade, and if they carried out the conditions laid down for the periods of training the Trade Unions would even accept them as members. The shipbuilding and engineering trade and the aircraft industry had now completed their reports, and the reports of a number of other trades, which would absorb almost as many men as required training, would be issued within the next two or three months. Until the necessary arrangements had been made, it was impossible for Local Committees in the various centres to formulate schemes of training, because there were no regulations under which the training was to be given, and no assurance that the men when trained would be properly treated by the employers. The Ministry of Pensions was doing all it could to deal with those disabled soldiers who needed outdoor employment, such as those suffering from tuberculosis, shell shock, etc. Arrangements were being made, in connection with the Board of Agriculture, to provide training in market gardening, and the authorities at Kew Gardens had offered to train men in horticulture. These employments, however, required a certain amount of energy which many of the disabled men were not able to devote to them, and an appeal might be made to the patriotism of golf clubs to provide light employment for such men. There were serious difficulties with regard to one-armed men, and a great deal of gratitude was due to the Lord Roberts' Workshops

for the help they had given in providing special employment for such men. It was not impossible to train them for many employments, and some were now earning more wages than they did in pre-war days. He felt the great need was to stir up public opinion with regard to the whole subject; the public should know what was being done and what facilities were being offered for the training of discharged soldiers. Advertising of that kind was being carried on at the present time in many parts of the country by means of lectures, illustrated by lantern-slides and cinema films, giving full particulars of all the facilities that were being offered. No one could be more anxious than the Minister of Pensions that everybody should know what was being done, and no effort would be spared to provide all the facilities that discharged soldiers required. The Ministry of Pensions hoped that by the end of February there would not be a single disabled man in this country who would not have ample provision made for his instruction either in technical schools, most of which had come forward and rendered valuable assistance, or in the various workshops where special courses of training, extending over periods of from six months to three years, had been established, and where the men would receive a good living wage.

MAJOR A. TUDOR CRAIG (Incorporated Soldiers and Sailors Help Society) said it was very important to be able to guarantee permanent employment to the men in the trade in which they had been trained. He advocated that all those who were to undergo training should be most carefully selected to see that they were fit for the trade they proposed to enter. If they could carry on the same trade in which they had been occupied before the war it would be much better to let them do so, as they would have a much better chance of obtaining employment. At the present moment many of the men were a little off their balance, and had a very exaggerated idea of their own value. Employers would find that that was the case, and they would have great difficulty in dealing with such men. He had recently received a letter from an employer who had in his factory 867 men disabled in the war, and he wrote quite hopelessly of the future of those men, saying that they were extremely difficult to deal with. In Lord Roberts' Workshops, which he had the honour to control, exactly the same state of affairs prevailed. About 20 per cent. of the men were splendid and could earn good wages; 40 per cent. were men who liked to come and go as they pleased, and would not stick to their work; and the remaining 40 per cent. were really impossible to deal with. With regard to Major Mitchell's reference to one-armed men being largely dealt with at the Lord Roberts' Workshops, there were now nearly two hundred such men employed there, chiefly in connection with machinery. The speaker produced a walking-stick made by a one-armed man from part of the wing of a German aeroplane brought down in this country. He did not think that employers after the war would be prepared to take one-armed men into their employment when they could obtain able-bodied men to do the work, and he thought it was only at such institutions as Lord Roberts' Workshops that one-armed men could be guaranteed permanent employment. He hoped the necessity of guaranteeing the men permanent employment would be kept very strongly in view by all those who were dealing with the matter.

MR. DUDLEY B. MYERS (Queen Mary's Convalescent Auxiliary Hospitals, Roehampton) said that they were rather favourably situated at Roehampton, because the misfortune of men who had lost a limb was such as to attract the sympathy of employers throughout the country, perhaps to a more marked degree than in the case of other forms of disablement. The trouble at Roehampton had not been to find work for the men, but to find men for the work offered. The psychological aspect of the problem was, of course, a difficulty; there were so many men of different classes and temperaments at Roehampton, and the personal equation was always a difficulty. When the hospital was first started, its originators recognised that it would not be sufficient to supply the men with artificial limbs, but that it was necessary to provide them with some form of training for an occupation after they left. Lady Wantage at once came forward and offered to present and equip workshops in connection with the hospital, which were erected under the superintendence and on the designs of Major Mitchell. The hospital at Roehampton had an advantage in the large number of its patients, in that they could be dealt with collectively. There were never less than 550 there at a time, and those men could be not only dealt with individually but collectively. They had the stimulus of the example of others who were working there, and also the example of men who had gone through the training and were earning good money, and who came back to the hospital occasionally for the repair of their artificial limbs. The men at Roehampton were thus surrounded by many inducements of one kind and another, and the effect of these inducements was very marked. The author had mentioned the difficulty of inducing men to undergo training, and he believed that was a true statement of the position. The average man when discharged from the Army did not know what kind of work would suit him, and did not know what kind of training to take up. When a man had a definite disablement, however, such as the loss of a limb, one knew exactly what that man could do and what his limitations and capacities were. There were five different training sections at Roehampton, and the men were allowed to try them all in turn if they liked, until they found the work that suited them. Many of the men at Roehampton had the additional advantage of having first passed through the work-

shops equipped on similar lines at the Pavilion Hospital at Brighton, where they received every encouragement and an excellent training. About nine thousand men had been handled industrially at Roehampton; 40 to 42 per cent. went back to their old employment; 33 to 35 per cent. went back to their homes in different parts of the country, and took up some form of industry there; and about 25 per cent. of the men were prepared to accept work anywhere.

Sir Robert Armstrong-Jones, M.D., F.R.C.S., F.R.C.P., thought the subject of the paper was one of supreme and overwhelming interest. He had had some experience in dealing with mental cases, and he believed if those men could be taken from the towns into the country it would have a very good effect on them. He felt rather disappointed that the author did not look more favourably upon settling disabled soldiers upon the land.

Mr. Warwick Draper thought a point of great importance was the association of training in agricultural pursuits with medical treatment in village centres, especially in the case of men suffering from shell shock, neurasthenia, etc., who might be encouraged to restore the life in our countryside. Such men should not be employed in the hard work demanded by small holdings, but in such pursuits as intensive culture and horticulture, and in the trades ancillary to those. In that way there was a great opportunity to restore the social fabric of a re-created and healthy peasantry and yeomanry in England. The Committee with which he was connected, and of which Dr. Fortescue Fox was the Chairman, were working out a scheme to combine vocational training with medical treatment in the manner he had indicated.

Dr. R. Fortescue Fox expressed his gratitude for the service the author had done in definitely associating medical care with the great problem of re-education.

On the motion of the Chairman, a hearty vote of thanks was passed to Lord Charnwood for his interesting paper.

Lord Charnwood, in reply, said that he did not wish to pour too much cold water on the idea of small-holdings, but he thought there was a certain number of people who favoured that scheme and did not realise the difficulties involved in it.

OBITUARY.

Charles Hawksley, M.Inst.C.E.—Mr. Charles Hawksley died on November 27th, at the age of seventy-eight. He was born in Nottingham in 1839, and after being educated at University College, London, he entered the offices of his father, the late Mr. Thomas Hawksley, F.R.S. In 1866 he became his father's partner, and he continued the business after his father's death in 1893. The firm was mainly engaged in waterworks engineering, gas and sewerage works. Mr. Hawksley was President of the Institution of Civil Engineers in 1901, and was serving at the time of his death on the Council of the Institution of Mechanical Engineers.

Mr. Hawksley was elected a member of the Royal Society of Arts in 1902. His father was also a member from 1868 to the time of his death in 1893, and he served on the Council as a Vice-President of the Society from 1888 to 1892. His son, Mr. Kenneth Phipson Hawksley, is now a Fellow, having been elected in 1902.

GENERAL NOTES.

Faraday Society. — A general discussion on "The Setting of Cements and Plasters" will be held on Monday, January 14th, 1918, at 5.30–7.0 and 8.30–10.30 in the Rooms of the Royal Society of Arts. The following papers will be read: Dr. C. H. Desch (Glasgow), "The Mechanism of the Setting Process in Plaster and Cement"; Professor H. Le Chatelier, "Crystalloids *v.* Colloids in the Theory of Cements"; Mr. A. A. Klein (Worcester, U.S.A.), "The Constitution and Hydration of Portland Cement"; Mr. George A. Rankin, (Creighton, U.S.A.), "The Setting and Hardening of Portland Cement"; Mr. Bertram Blount, "The Setting of Cement in its Relation to Engineering Structures"; Mr. John Rhodin, "Note on the Colloidal Theory of Setting"; Mr. E. H. Lewis and Monsieur E. Deny, "The Effect of the Addition of Suitable Slag on the Setting Properties of Portland Cement"; Mr. W. J. Dibdin, "Ancient and Modern Mortars."

Victoria and Albert Museum.—A commemorative exhibition of the works of the late Auguste Rodin has been arranged at the Victoria and Albert Museum, and is now on view in the East Hall, near the Cromwell Road entrance. In the early months of the war, as will be remembered, Rodin gave to the nation, for preservation in the Museum, a magnificent group of his works, with the express intention of symbolising in the gift his admiration for British soldiers fighting side by side with his own countrymen. This collection, which is probably the largest individual collection of Rodin's works outside Paris, has now been supplemented by a number of other works, which their owners have generously lent to the Museum for this exhibition. Among these may be mentioned a marble group, "Les Benedictions," from the Tower of Labour; busts of Legros, Gustave Geffroy, Lord Howard de Walden, and Mrs. Charles Hunter; "L'homme au nez cassé," and a small version of Le Penseur.

Farthings.—The Chancellor of the Exchequer, replying to a question in the House of Commons on November 29th, stated that 42 tons of farthings, or 15,000,000 pieces, had already been issued in the eleven months of this year, an amount about three times the issue for the whole of 1914.

MEETINGS OF THE SOCIETY.

Ordinary Meeting.

Wednesday afternoon, at 4.30 p.m.:—

December 19.—Professor J. Wemyss Anderson, M.Inst.C.E., M.I.Mech.E., Dean of the Faculty of Engineering and Lecturer in Refrigeration, University of Liverpool, "Science and the Cold Storage Industry." The Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand, will preside.

Cantor Lectures.

Monday afternoon, at 4.30 p.m.:—

H. C. H. Carpenter, M.A., Ph.D., M.Inst. M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology. "Progress in the Metallurgy of Copper." Three Lectures.

Syllabus.

Lecture III.—December 17.—Converter practice—Refining and casting—Treatment of tailings—Flue-dust treatment—Extraction and purification of white arsenic—Electrolytic refining at the Raritan works—Production of commercial copper. Pyritic smelting at the Tennessee Copper Co.—Hydro metallurgy—Leaching at Chuquicamata—Present-day methods of extraction of native copper at Calumet—Treatment of mixed sulphide and oxide low-grade ores. Tendency of modern metallurgy.

Position of the industry in Great Britain to-day. Importance of copper refining—Chief commercial varieties of copper, including tough-pitch arsenical copper—Need for exhaustive inquiry into the various aspects of the industry from the standpoint of Empire requirements, and of action to be taken on the basis of the results of the inquiry.

Papers to be read after Christmas:—

Lord Leverhulme, "The Relations between Capital and Labour—Reasonable Hours, Copartnership, and Efficiency." W. A. Appleton, C.B.E., Secretary of the General Federation of Trade Unions, will preside.

Sir William H. Clark, K.C.S.I., C.M.G., Comptroller-General of the Commercial Intelligence Department, "The Organisation of Commercial Intelligence." The Right Hon. Lord Faringdon will preside.

Alexander Newlands, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in the British Isles."

Frank Stuart Courtney, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." Sir John Snell, M.Inst.C.E., will preside.

Martin O. Forster, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." Sir William A. Tilden, D.Sc., LL.D., F.R.S., will preside.

Maurice B. Adams, F.R.I.B.A., "Picturesque Architecture." Sir Aston Webb, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

Wm. Frecheville, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of Mineral Resources of the Empire." Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

Alfred Dickinson, M.Inst.C.E., "Water Power in India."

H. M. Surtees Tuckwell, M.I.Mech.E., "The Tata Iron and Steel Works" (India).

Sir Henry Ledgard, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India."

Hon. Sir Dinshaw E. Wacha, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912-17, "British Guiana."

C. du P. Chiappini, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

The following series of papers has also been arranged, dealing with the Application of Scientific Research to the Development of particular British Industries:—

Reginald S. Clay, D.Sc., Principal of the Northern Polytechnic Institute, "The British Pianoforte Industry."

George Martineau, C.B., "Sugar from several Points of View."

John B. Farmer, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. Lawrence Ball, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

Sir William George Watson, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." Sir Arthur D. Steel-Maitland, Bt., M.P., will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

January 17, February 14, March 14, April 18, May 30.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

February 5, March 5, April 30.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced) :—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." Three Lectures.

January 21, 28, February 4. At 8 p.m.

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Economic Condition of the United Kingdom before the War: The Real Cost of the War: and Economic Reconstruction." Three Lectures.

February 18, 25, March 4.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

JUVENILE LECTURES.

Wednesday afternoons, at 3 p.m. :—

P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, "Animal Camouflage." Two Lectures.

January 2 and 9.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DECEMBER 17...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Professor H. C. H. Carpenter, "Progress in the Metallurgy of Copper." (Lecture III.)

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Rev. A. H. Finn, "The Mosaic Origin of the Pentateuch."

British Academy, in the Theatre, Burlington-gardens, W., 5.30 p.m. (Schweich Lectures.) Rev. Professor C. F. Burney, "Israel's Settlement in Canaan: the Biblical Tradition and its Historical Background." (Lecture II.)

Engineers, Society of, at the Geological Society, Burlington House, W., 5 p.m. Mr. E. W. C. Kearney, "High Speed Railways."

Geographical Society, Burlington-gardens, W., 8.30 p.m. Second Lieutenant J. M. Wordie, "The Drift of the 'Endurance.'"

Engineers, Junior Institution of, 39, Victoria-street, S.W., 7.30 p.m. Mr. C. R. Turner, "Engineering in the Brewing Industry."

East India Association, Caxton Hall, Westminster, S.W., 4.15 p.m. Sir Charles Armstrong, "Commercial and Industrial Development in India."

TUESDAY, DECEMBER 18...Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Address by Mr. A. P. Trotter.

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. E. H. Cunningham Craig, "The Prospective Oilfields of Barbados."

Statistical Society, at the Surveyors' Institution, Great George-street, S.W., 5.15 p.m. Sir R. H. Rew, "The Prospects of the World's Food Supplies after the War."

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Mr. W. L. L. Brown, "The Buenos Aires Western Railway Tunnels under the City of Buenos Aires."

WEDNESDAY, DECEMBER 19...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Professor J. Wemyss Anderson, "Science and the Cold Storage Industry."

Röntgen Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Mr. P. Bolton, "Computation of Wind Velocity from Pilot Balloon Observations." 2. Mr. E. G. Bilham, "The use of monthly Mean Values in Climatological Analysis."

Geological Society, Burlington House, W., 5.30 p.m.

Microscopical Society, 20, Hanover-square, W., 8 p.m. Professor W. Bateson, "Cytology and Genetics."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Lord D'Abernon, "Public Health and Alcoholism in Women."

Colonial Institute, Caxton Hall, Westminster, S.W., 4 p.m. Mr. W. C. Dawson, "Democratic Ideals in Imperial Reconstruction: some neglected dangers, and suggested safeguards."

THURSDAY, DECEMBER 20...London Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Mr. J. Slater, "Old Marylebone."

Royal Society, Burlington House, W., 4.30 p.m.

British Academy, in the Theatre, Burlington-gardens, W., 5.30 p.m. (Schweich Lectures.) Rev. Professor C. F. Burney, "Israel's Settlement in Canaan: the Tradition and its Historical Background." (Lecture III.)

Chemical Society, Burlington House, W., 8 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. 1. Mr. E. A. Ashcroft, "A Neglected Chemical Reaction and an Available Source of Potash." 2. Mr. J. J. Garrard, "Syphoning Gravel."

Japan Society, 20, Hanover-square, W., 3.30 p.m. Mr. J. Blair, "The Japanese Mercantile Marine."

Concrete Institute, 290, Vauxhall Bridge-road, S.W., 5.30 p.m. Messrs. H. K. Dyson and E. Marsland, "The Effects of Fire on Reinforced Concrete Buildings as demonstrated by some Recent Examples."

Camera Club, John-street, Adelphi, W.C., 8.15 p.m. (Ten Minutes Lecturettes by Member.)

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Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, DECEMBER 21, 1917.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

CANTOR LECTURE.

On Monday afternoon, December 17th, Mr. H. C. H. Carpenter, M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology, delivered the third lecture of his course on "Progress in the Metallurgy of Copper."

On the motion of the Chairman, a vote of thanks was accorded to Professor Carpenter for his interesting course.

The lectures will be published in the *Journal* during the Christmas recess.

INDIAN SECTION.

Thursday afternoon, December 13th; Rt. Hon. Lord Islington, G.C.M.G., D.S.O., Under-Secretary of State for India, and subsequently Sir Charles C. McLeod, in the chair. A paper on "The Trade of India with Russia, France, and Italy," was read by Mr. D. T. Chadwick, I.C.S., Indian Trade Commissioner.

The paper and discussion will be published in the next number of the *Journal*.

JUVENILE LECTURES.

A course of two lectures, adapted to a juvenile audience, will be delivered on Wednesday afternoons, January 2nd and 9th, 1918, at 3 p.m., by Mr. P. Chalmers Mitchell, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, on "Animal Camouflage."

Special tickets are required for these lectures. They can be obtained on application to the Secretary.

A sufficient number of tickets to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply for them at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and can be obtained by Fellows on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

Wednesday, December 19th, 1917; The Hon. Sir Thomas Mackenzie, K.C.M.G., High Commissioner for New Zealand, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Anderson, Gilbert, London.
Attwater, Richard, Preston.
Baroda State, The Minister of Education, Baroda, India.
Boote, Edgar M., Coventry.
Bradshaw, Granville E., Walton-on-Thames.
Chadwick, David Thomas, I.C.S., Kent.
Coatalen, Louis, Wolverhampton.
Diamant, A. St. John, L.R.I.B.A., Egypt.
Forster, Martin O., D.Sc., Ph.D., F.R.S., London.
Lo Tian Cheok, The Hon., Borneo.
Mastin, John, D.Sc., Litt.D., Kenyon.
Mort, George Frederick, London.
Pegler, Frank, Retford.
Sempill, Squadron Commander, the Master of, R.N.A.S., London.
Ware, Alfred George, Bournemouth.
Willis, Thomas Wilkinson, Sheffield.

The following candidates were balloted for and duly elected Fellows of the Society:—

Berwick, F. W., London.
Delpech, Reginald, London.
Hackett, W. W., Birmingham.
Hall, Robert Swainson, Portuguese Congo.
Lake, Joseph Lenegan, London.
Lambert, Arthur Reginald, Sevenoaks.
Laws, Robert George, London.
Samuel, Henry, London.
Seth, Mesrovb Jacob, Calcutta.
Waring, S. J., London.

THE CHAIRMAN, in opening the meeting, said no one could over-estimate the enormous possibilities associated with the cold storage industry. It had changed the conditions in New Zealand from profitless occupations to prosperity. Before the frozen meat industry was introduced, sheep in New Zealand were not worth more than sixpence or a shilling, and the transformation that had taken place read like a fairy story. Immediately before the introduction of cold storage, there were about 12,000,000 or 13,000,000 sheep in New Zealand, and it was then thought that not more than a quarter of a million could be exported without depleting the flocks and herds, but the export had now reached 6,000,000 annually, and New Zealand had sent to this country 47·5 per cent. of the total mutton and lamb that had been imported, 106,000,000 carcasses having been exported to this country by New Zealand up to the end of 1916. With regard to the dairy industry, before the organisation of that industry in New Zealand, and the application of cold storage, the total exports were £4,000,000, whereas now they were £7,000,000 per annum. If that could be done in a small country like New Zealand, great things might be expected with scientific study and research.

The paper read was—

SCIENCE AND THE COLD STORAGE INDUSTRY.

By J. WEMYSS ANDERSON, M.Eng., M.Inst.C.E., M.I.Mech.E.,

Dean of the Faculty of Engineering, and Lecturer in Refrigeration, University of Liverpool.

The value of perishable produce imported into this country, subject more or less to refrigeration, was, pre-war, about £130,000,000 per annum. The greater amount* of this sum was represented by the values of beef, mutton, pork, rabbits, bacon, ham, butter, cheese, eggs, fruit, lard, margarine, poultry and game. In future returns fish will, no doubt, occupy an important position. In normal peace times a good and cheap food supply is always highly placed in the list of *desiderata* of national prosperity. Under war conditions, food supply is classed under the heading of "National Importance." Further, transport and preservation are always prime factors in food supply, but in an island empire they become factors of the first order.

It is abundantly evident that the most natural means of preserving foodstuffs, viz., by means of low temperatures, has gained the confidence of our merchants, and the cold storage industry to-day is a striking example of the successful combination of science, commerce, and industry. It would be useless to contend that in this combination there are no weak links in the chain that binds the three together—indeed, the object of this paper is to point out one of the weak links and suggest methods for strengthening it.

* See Appendix I.

If "reconstruction" has any meaning at all, it is that in the years immediately following the declaration of peace, there must be no weak links in any industry; all the chains must be uniformly strong and capable of withstanding the combined pull necessary to maintain our commercial supremacy. It had been the intention of the author to give a brief history of the cold storage movement, but he has found it impossible to do justice to the subject in a way suitable to the scope of the paper. The history, however, reveals four outstanding features:—

(1) That its merchants have been typically British—indeed, it is hard to imagine a more striking example than the cold storage industry affords of the success of the spirit of enterprise and love of adventure, which, combined with a stern sense of equity and justice, has always characterised British commerce.

(2) That refrigerating engineers have been in no sense less typical, inasmuch as the methods employed are scientifically sound, the machines of the leading manufacturers are thoroughly reliable, and the necessary low temperatures for the transport and storage of food have been made a sound commercial proposition.

(3) That refrigeration has played a most important part in the development of some of our Colonies—particularly Australia and New Zealand. Refrigeration will still remain of the first importance to these Colonies, and will become a greater factor in Canada, South Africa, India and Egypt. It should be said that Canada has done excellent work in refrigeration, both scientifically and practically; but it would not appear that her development has depended on it to the extent that obtains for Australia and New Zealand.

(4) That while the applied science of the engineer has done much for the advance of cold storage, pure science has in this country done little or nothing for the commercial preservation of foodstuffs.

This is the weak link previously referred to. This link can be strengthened, indeed, it must be strengthened if this country is to prevail.

The principal foodstuffs at present cold stored (see Appendix I.) can be roughly divided into three classes:—

(1) Produce whose life history is finished, such as all classes of meats, poultry, rabbits and fish.

(2) Produce whose life history is not finished, such as fruit and eggs.

(3) Milk and produce from milk—cream, butter, and cheese.

The mention of "life history" is sufficient to show the peculiar blend of knowledge required to deal with proper understanding with the materials mentioned. It is astonishing to what heights the merchant and engineer have already soared; but, however keen the scientific penetration of those practically engaged in the cold storage industry to-day, there can be no doubt that pure scientific, medical, and veterinary knowledge and research must be brought to bear on the subject.

What are the types of problems awaiting solution? Taking examples from the three sections in order, there is first the problem of chilled beef.

It has been found that with good rearing of sound stock, combined with scientific methods of slaughter, and a thorough system of veterinary inspection and hygienic after-care, beef can be kept in the chilled (soft or unfrozen) state for five or six weeks. This time permits of a voyage from North or South America, together with the time necessary for collecting the cargo at one end and its distribution at the other—in this country. This present time allowance cuts out all possibilities of a chilled beef trade with Australia or New Zealand with low temperatures only.

Methods have been propounded and even carried out. Are these methods sound from a dietetic standpoint? Can science aid our Colonies with a definite pronouncement on the subject? It remains to be said that chilled beef is financially sounder than frozen beef.

Then again, with all classes of meats, poultry, and rabbits, certain troubles manifest themselves from time to time—such as mould. Often the troubles are epidemic and caused by ignorance or carelessness prior to shipping, while often only a small percentage of an overseas consignment is affected and the source of trouble cannot be found by the trader. The loss—whoever bears it financially—is not only a loss of wealth, but a loss of food to the nation.

Then again there is the problem of fish. Fish has been preserved in many ways, but it is safe to say that refrigeration is destined to outrival, in bulk, all other methods. Research work is urgently needed in this direction, both with respect to meeting periods of glut * and for general preservation and transport. Such work should not be confined to narrow limits; a very broad view must be taken and all methods reviewed, the main questions to be determined being:—

(1) What kinds of fish will stand preservation the best?

(2) What are good methods, and, if possible, the best with each kind of fish?

(3) The seasons of the year best adapted for each form of preservation.

(4) The food values and general effect for each method of preservation on the principal kinds of fish.

In refrigeration alone, no one method will hold good for all kinds of fish—some will not stand freezing at all, some will stand it well for a short period, others for long periods. Some will require quick or sharp freezing, others will stand a slower method. Most fish will require gutting before treatment, others will probably keep sufficiently long in a frozen state ungutted.

When the best methods have been determined, there still remains the problem of educating the public taste. It will be useless to preserve thousands of tons of fish by a special method if the markets will not take them, or if our methods of transport do not conform to the scheme.

It remains to be said that, in the British Isles, the problem is mainly how to get the fish to the markets in a fresh state. Cold storage methods will help this, but the wider researches are required for the fishermen who go far to sea, and also for fish imported in a frozen state from our Colonies.

With respect to the second section, the preservation of both fruit and eggs, if properly understood *and applied*, would mean a great saving of wealth to the country, and could also only mean better health. It seems very doubtful, at the moment, if new laid eggs will ever again sell in any part of the country at 6*d.* a dozen; such a low figure was reached in the past, due to a prolific season and with no knowledge or means of keeping them fresh available to the farmer.

With respect to fruit, refrigeration has enabled this country to enjoy a perpetual autumn; but the methods that enable Australian fruit to be eaten in a sound condition in this country are not applied to home grown fruit. Why?

The fruit merchants of this country have had to depend on the pure science of countries other than our own to help them to keep material whose life history has not been finished.

* See Appendix III.

Fruit and vegetables offer an immense field for research.

The third section, milk and its products, opens up a still greater field—a field that should be made either national or municipal or both.

Nature never intended milk to come into contact with air—the penalties attached to breaking this rule are very great.

Sterilization as usually adopted hopelessly destroys its structure, and, no doubt correspondingly destroys its food value. Common-sense deductions point to mechanical milking into covered vessels, the whole to be cooled down to 3° or 4° C. as soon as possible after the milking operation, and then kept away from the air till the time of consumption.

The municipality of Paris adopted these methods for infant feeding, and has—or at least had, before the war—its own farm on the now historic Marne.

Milk so treated and kept cold will keep quite sound, with ordinary commercial handling, for over a week—theoretically, it should last for months. Why, then, are not these fundamental facts employed and insisted upon?

The proper methods of making and keeping of butter and cheese render it essential to adopt low temperatures, so that milk and its products require special attention from the refrigerating point of view, and concern the nation in a most vital part—infants and invalids.

The few problems selected must only be regarded as typical, the number awaiting solution, including engineering, are almost legion.

In chemical, industrial, agricultural, horticultural, brewing, and manufacturing operations, refrigeration is already employed, but to an absurdly limited extent. A proper knowledge of low temperature effects would lead to great developments. This can be said without the slightest hesitation.

Wheat * (and other cereals), if stocked in this country in "reserve" quantities, will require very special attention in storing. Wheat belongs of course to the second section, the life history not being finished, and it will stand low temperatures particularly well, while its parasites would be either killed off, if existing, or prevented from forming. Further, wheat kept dry and cold would be in an ideal condition for long period storing.

The main questions may now well be asked: What has stood in the way of scientific development in the past, and what are the suggestions for the future?

* See Appendix II.

With respect to low temperature work, the answer to the first question can be readily divided into two main reasons:—

(1) The want of a bond or link between pure science and industry.

The present time is most opportune, and if the man of science will only realise that laboratory results are not by any means conclusive, he will find the man of commerce will help him in researches of a practical nature; the net result will be more commerce and a higher and better scientific knowledge.

(2) The man of science has not had facilities in his laboratory for low temperature work. Many researches stop short at the melting-point of ice or a little below.

Every seat of scientific learning should have a refrigerating apparatus as part of its equipment —not a toy machine, but a self-contained cold storage with arrangements for a "cold" reserve (large quantities of calcium chloride brine) for periods of interruption. No research of any kind where temperature is a function can be considered complete that does not go down to the lowest limit reasonably obtainable, yet how many institutions are there where such investigations are possible? The lack of such facilities in the light of recent advances all over the world, will constitute a serious disadvantage to our men of science, and the question must be taken up by every scientific body in the kingdom.

The suggestions as to the future are partly answered, but only partly.

If every scientific institution in the country was provided with adequate low temperature installations, there would still remain, from the cold storage point of view, the want of that link which is missing at the moment. This link will, no doubt, be forged by the Advisory Committee of the Privy Council on Scientific and Industrial Research, whose particular and important function is to promote research and *weld science to industry*.

The Cold Storage and Ice Association is working in close touch with this Committee, and has intimated its willingness to give any practical help in the way of publishing results.

The Association of Cold Stores Proprietors and Managers, and also the British Engineers' Association, have also expressed themselves as being interested in low temperature research work, and both have also been in communication with the Advisory Research Committee.

The Institution of Mechanical Engineers have a standing Refrigeration Research Committee,

whose first report contains suggestions for a unit of refrigeration (one calory per second) and a standard unit refrigerating machine, which, no doubt, will become the British standard.

The War Office, Board of Trade, Board of Agriculture and Fisheries, Ministry of Munitions, Admiralty, Ministry of Food (with its special section of Cold Storage and Inland Transport of Food), Local Government Board, Ministry of Reconstruction, Ministry of Shipping, and the Board of Education, are all more or less affected by the cold storage problem. In short, it is a matter of urgent national importance, but inasmuch as it has been previously shown greatly to affect our Colonies, it becomes an Empire matter.

The cold storage industry then, has a great claim on science; but low temperature study, education and research touching so many Government Departments, and with such boundless possibilities for so many branches of science, commerce and industry, and also for Empire development, it is fitting that the Royal Society of Arts should take the matter into its own consideration.

The author therefore suggests:—

(1) That institutes of research and schools of refrigeration * be instituted in London and Liverpool. (This suggestion has been approved by the Cold Storage and Ice Association.) These institutes would be attached to learned institutions, and would act as centres for research work and the higher instruction of graduates (or others duly qualified) in medicine, science, engineering and veterinary science from home and colonial universities. They would also keep definitely in touch with Government Departments and associations interested in low temperature work.

(2) That every seat of scientific learning should provide facilities for low temperature study and research.

(3) That every engineering school of university rank should provide facilities for refrigerating engineering study and mechanical research.

(4) That the principal technical colleges and schools under the Board of Education should be provided with facilities for instruction in mechanical refrigeration.

It remains to be said that we are the only country in the world where the purely scientific side of cold storage work has been neglected—happily, it would appear as if this stigma was about to be removed.

I am authorised by Sir Frank Heath, of the Department of Scientific and Industrial Research, to announce that the Government intend to take up research as applied to Cold Storage in a comprehensive manner.

* See Appendix IV.

APPENDIX I.

The actual values of the principal foodstuffs imported, subject more or less to refrigeration, were in 1914 as follows:—

Beef	£19,060,371	
Mutton	11,410,310	
Pork	2,360,722	£32,831,403
Rabbits	747,643	
Bacon	18,225,568	
Hams	3,063,078	
Meat (unspecified)	1,693,984	
Poultry and game	943,726	£24,673,999
Total for meat		£57,505,402
Butter	24,014,276	
Cheese	7,966,162	
Eggs	8,652,850	
Fruit	11,118,051	
Hops	558,741	
Lard	4,750,943	
Margarine	3,077,361	£60,138,384
Total		£117,643,786

The most interesting comparative import figures are:—

	1914.	1915.	1916.
	£	£	£
Poultry and game	943,726	637,852	668,407
Butter	24,014,276	27,022,745	18,977,450
Cheese	7,966,162	11,107,100	12,945,450
Margarine	3,077,361	5,751,253	8,983,007

APPENDIX II.

The following figures, taken from the Royal Society's report relating to the "Food Supply of the United Kingdom for 1916," supplements the information given in Appendix I., in conveying the magnitude of the perishable produce trade. The quantities are metric tons, and deal with home as well as imported produce:—

Description.	Average, 1909-13.	1916.
Cereals	4,865,000	5,074,000
Meat, poultry, game, and lard	2,848,000	2,555,500
Milk	4,500,000	4,350,000
Butter	321,000	229,000
Margarine	118,600	235,000
Cheese	147,000	110,000
Condensed milk	55,200	57,390
Eggs	258,000	195,000
Fish	848,400	470,000
Vegetables (other than potatoes)	1,232,000	989,820
Fruit	1,271,000	1,014,000

APPENDIX III.

The great value of fish as a food, and the particular value of herrings, merits attention being drawn to the following figures, extracted from the *Fish Trades Gazette* for October 20th, 1917, and shows that by far the greater weight of herrings landed in 1913 were *exported* :—

		(1913.) cwt.
Landed from British fisheries . . .		12,183,000
Exported fresh . .	cwt. 1,167,000	
" cured . .	" 8,795,000	
		9,902,000
Balance . .		2,221,000
Fresh herrings imported		1,236,000
Available for home consumption .		3,457,000

In October, 1913, the herrings landed per day at Yarmouth averaged 65,000 cwt.—an astonishing total.

APPENDIX IV.

Refrigeration forms an optional subject in the Honours, or fourth year of study (post Graduate to Ordinary degree), in Mechanical Engineering, under the Faculty of Engineering, University of Liverpool.

No scheme has yet been possible on lines similar to those laid down by the French Association of Refrigeration (Special Committee report, October, 1910), which was to the effect that a Diploma of Refrigerating Engineering be established, open only to candidates with an approved degree, or who can otherwise "justify five years' constant industrial practice in some manufacture."

The scheme included attendance on lectures given at the High School of Aeronautics and Engineering (Paris), in the following subjects, each subject being under a separate professor :

1. Science of Refrigeration.—Subjects: (*a*) Theory of Physics ; (*b*) Mechanics and Thermodynamics; (*c*) General and Biological Chemistry; (*d*) Mathematics ; (*e*) Legislation.

2. Refrigerating Machinery.—Subjects: (*a*) Practical Physics ; (*b*) Refrigerating Plants ; (*c*) Building and Insulating Materials.

3. Applications of Refrigeration.—Subjects: (*a*) Hygiene ; (*b*) Food ; (*c*) Mining, Metallurgy, and Public Works ; (*d*) Agriculture and Agricultural Machinery ; (*e*) Physical and Chemical Industries : (*f*) Application and Use of very low Temperatures.

In the report the actual professors suggested are named.

It would appear that the schools or institutes of refrigeration proposed for this country could, with advantage, adopt a similar syllabus. Such interworking is absolutely essential for successful research and instruction in such a subject as refrigeration.

DISCUSSION.

MR. GILBERT ANDERSON, in opening the discussion, said a great deal was heard about the want in this country of scientific research, but in his opinion no country had attained such high eminence in scientific research as Great Britain had. It was owing to the researches made by British scientists, chemists and engineers, that the problem of refrigeration had been successfully solved. That problem had been solved thirty-five years ago by British brains and British energy, but from that time to the present day the Government had rendered no assistance whatever to it, although no other country in the world was so dependent upon refrigerated food. All the frozen meat that came to this country from New Zealand was submitted to veterinary inspection there, but there was no kind of inspection laws here. It would be an excellent thing to have an international system of meat inspection. In this country investigators worked in water-tight compartments, and there had never been any link between scientific research on the one hand and merchants on the other. Merchant adventurers many years ago took up the question of refrigeration and had the necessary machines built, and made arrangements for supplying the people of this country with frozen meat. If it had not been for that frozen meat the Government would never have been able to carry on the war, and yet the Government had not made up its mind to refer the question of cold storage to one particular department, as it ought to do. Refrigeration covered very many branches, and the whole question needed to be studied in all its aspects. The moment life was taken away from an animal, bacteria became active and decay set in, but it was not yet known exactly what decay of meat meant —how it went on and how it was to be prevented. Then there were the mechanical changes to be considered in the structure of the tissue. Another question that needed to be investigated was why there was a depression of the market in frozen meat every now and then, and so much waste in other things, such as fruit and eggs. No animal should be permitted to be killed for food in this country except in a municipal abattoir under proper supervision, and in connection with those abattoirs there should be cold storage facilities and proper plant for utilising the by-products. He hoped it might be possible to induce the Government to let one particular department, say the Board of Agriculture, take up the question of cold storage.

MR. CHARLES J. TABOR said he was glad the question of refrigeration was being brought to the notice of the public, because many people still

thought it was a chemical and not a mechanical one. As the founder of the frozen rabbit trade, about three or four years after the advent of refrigerated meat, he had had a very wide experience in the subject. Shortly after that he was appointed one of Lloyd's surveyors, and he soon saw that it was not only his duty to save the underwriters from heavy claims, but also to find out the reason for the damage that occurred to the goods. He had made some very wide researches into the growth of mould on refrigerated produce, and he was glad to find that scientific people had now taken the matter up. That mould could be prevented if equable temperatures were maintained. As the author had said, some food substances required different temperatures from those required by others. The chief point to be remembered was that both freezing and thawing operations required to be carried on slowly. The whole process of freezing consisted of disintegration; all food substances, meat even more than fish, contained a large proportion of water, and its violent expansion at the time of freezing must of necessity cause rupture of the tissues. He did not think fish could ever be advantageously frozen, because, although frozen fish was quite wholesome, from a gastronomic point of view it was very much injured in the process.

Mr. Charles Chamberlin said he would be glad if the author could state whether the fruit put on board ship in a South African port had an opportunity of having the heat removed from it. The expense of bringing fruit from South Africa had been very great, owing to want of knowledge of how to treat it, and the difference in the condition of different cargoes of fruit when they arrived in this country was very noticeable. He would like to know the reason for that. The fruit was inspected by the authorities before it was put on board, but it was not everyone who had the facilities for cooling it before it was shipped, and when the fruit arrived in this country it was often in a soft condition. A complaint was frequently made, chiefly with regard to peaches, that the fruit was rotten in the middle. He did not think that was due to decay. The solidity of the matter that was frozen was not the same, the stone of a peach being about 80 per cent. harder than the flesh. When the fruit was exposed to the normal temperature the flesh became of that temperature, but the stone inside remained cold and hard for days after it came out of cold storage. The action of the cold stone on the soft flesh produced what people usually called decay, but the question was whether it was decay or merely the action of the cold stone on the soft flesh. When fruit was put into cold storage it should not be in too immature a state nor should it be put in ripe. He did not think it was yet known how to bring fruit to this country in perfect condition.

Mr. J. Thom thought that insufficient attention was paid to the subject of cold storage from an educational standpoint. The science of that subject was not different from other sciences taught in schools and colleges, as it approached closely to the subject of heat, and the mechanical part of the subject was the only one that did not fit in with the ordinary subjects studied in colleges. He thought it was quite possible for technical classes on refrigeration to be started in the principal technical colleges and schools, as suggested by the author, especially in view of the fact that this country was very dependent for its food supplies on cold storage.

Mr. F. W. J. Moore thought the remarks made by Mr. Chamberlin showed the necessity for some systematic method of research into the question of low temperatures. If an article could be frozen it was simpler to deal with than another product which must not be frozen. He had been connected with the cold storage of fruit ever since the subject was first brought forward, and he thought the question of temperature had been neglected far too long. More was known about the matter now, and it was realised that certain fruits would keep if the temperature was low enough. Apples, for instance, would not suffer even at 32 degrees, but fruits coming from the Cape were very different articles to deal with. With regard to Mr. Chamberlin's remarks about the stone affecting the fruit, as a practical fruit canner he knew that difficulties were experienced in canning fruit containing stones, and there might be some trouble arising from the stones when carrying fruit at low temperatures. Certain fruit such as peaches, apricots, plums and oranges, should be pre-cooled, but he did not think it was necessary in the case of apples. Research was certainly required into the question of temperature, and he agreed with Mr. Gilbert Anderson that the Government should hand the matter over to one particular department. Such things as hops and tobacco would be very much improved if it was known in what temperature they should be kept.

Mr. George Daniels said the paper dealt largely with research applied to foodstuffs, which, in view of the present shortage of food and the possible future world shortage, was very important, but research should also be carried out in the other branches of the subject such as the engineering and chemical branches. The work had up to the present been more or less fragmentary, there being no system by which those dealing with the various aspects of the subject—physical, chemical, and engineering—could all work together. He thought very good results might be obtained by the establishment of schools of refrigeration in various parts of the country, as had been suggested. Personally, he was concerned more particularly at the present time with refrigeration applied to the

chemical industry, and there practically each case brought out special problems of its own, for the solution of which all the various periodicals had to be studied in order to find out what different men had done. One use to which the schools of refrigeration might be put would be to collect and co-ordinate those data which had been obtained in the past, and might be obtained in the future, and keep them together in a handy form for the benefit of those engaged in the refrigeration industry. The need for research was clearly shown by the fact that when, about two and a half years ago, his own firm wanted to put up a plant in connection with chemical work for war purposes, and had to go down to a temperature of -50 degrees Centigrade, they were only enabled to carry out the work by the use of certain thermo-dynamic data published by the Royal Society. The proposed refrigeration schools might also be used for instructing the public, many people still being prejudiced against cold stored food, and for overcoming the diffidence displayed by many manufacturers towards correct scientific work.

THE CHAIRMAN (the Hon. Sir Thomas Mackenzie, K.C.M.G.), said that fifty years ago the Society of Arts set up a committee to investigate the subject of refrigeration, although it seemed to have lapsed about 1881. Speaking as one from abroad, he was surprised that this country, depending, as it did, to such a large extent upon food supplies from abroad, had not been able to move its Government to act in the matter. The scientific men, manufacturers and business men of this country were second to none, and yet there was that missing link which it seemed impossible to find. The Dominions overseas did not possess the scientific men that this country had, and the people there had had to pick up their knowledge as best they could, and department after department was established for the purpose of furnishing such information as that which had been asked for by Mr. Chamberlin. New Zealand had not yet developed her fruit industry, but in the dairy industry butter and cheese were being manufactured and exported which previously it had been impossible to export. The Government had stepped in and appointed instructors, and until war broke out they had employed scientific men in this country to report on the condition of the butter and cheese that arrived here. Those scientific men reported to the instructors and experts in New Zealand, who informed the managers of the dairy factories if anything was wrong with their produce. The instructors and managers would unite in trying to discover what was wrong, and they were usually successful in doing so. In the Colonies people had had to depend upon their own efforts and fight their own way through difficulties. He hoped that the paper read that afternoon, and the remarks made by the speakers in the discussion, would have some fruitful result, and that the Government would be induced to take the matter up seriously, and supply the missing link between science and industry.

ALDERMAN MORGAN HOPKIN suggested that a resolution, emanating from the Chairman, should be passed by the meeting requesting the Prime Minister to receive a deputation of gentlemen from the Royal Society of Arts on the subject in question, which was one of Imperial importance.

THE CHAIRMAN said he had no doubt the Society would take into consideration the suggestion made by Mr. Hopkin, but he did not think it was his duty to move in the matter, which was a purely domestic one for this country.

PROFESSOR WEMYSS ANDERSON, in reply, said that the questions asked by Mr. Chamberlin about the cold storage of fruit showed the great need there was for research. He thought that as a matter of fact pre-cooling was of benefit in dealing with all kinds of fruit. Nature seemed to indicate that if the fruit was to be kept by refrigeration at all it ought to be cooled down as soon as possible. With regard to the question whether the trouble in cold storing stone fruit was due to decay or the action of the stone, nature of course intended that the stone should be reached by the outer covering eventually breaking down, and, if the outside was prevented from decaying in the ordinary way and breaking up so as to free the stone, nature tried to find some other way, and it would be found that the apparent decay was undoubtedly the breaking-up of the tissue which occurred from the inside and spread from the stone outwards. In fruits where there were such entirely dissimilar materials as the outside structure and the stone, such breaking up from the inside outwardly often took place. He agreed that research was also needed with regard to temperature. When once cooling was commenced the temperature ought to be kept as even as possible; the steadier the conditions the better. He agreed that work in the past had been carried on far too much in watertight compartments, and he hoped that the co-ordination of research would soon be taken in hand.

A vote of thanks to the author for his interesting paper was then proposed by the CHAIRMAN, and carried unanimously, and the meeting terminated.

CULTIVATION OF THE WOOD-OIL TREE IN UNITED STATES.

Several years ago the United States Department of Agriculture undertook the study and experimental cultivation in that country of the Chinese wood-oil tree, with encouraging results. It found that the tree grew and fruited well in South Carolina, Florida, Alabama, Louisiana, Mississippi, Georgia, Texas, and California, but

could not fix the northern limit of cultivation in the United States in the absence of data as to how low a temperature the wood-oil tree will stand without injury. However, the tree has withstood a temperature as low as 4° F.; and as it drops its leaves in winter and does not wake up early in the spring, it is not likely to be injured by late frosts. To quote further from the Department's bulletin on the subject:—

"The Chinese wood-oil tree (*Aleurites fordii*) is probably not very long-lived, and would be comparable in this respect to the silver maple. The flowers come out before the leaves; they are fully as large as catalpa flowers, and the tree in bloom is a very pretty sight. As an ornamental tree the wood-oil is likely to prove about as desirable as the catalpa, but the soft wood is of little value, and, like many other soft-wooded trees, the branches break off easily in heavy winds.

"The tree commences to bear fruit when four or five years old. The fruits are the size of small apples, and contain from two to eight large, oily seeds that are reported to be poisonous, and should not be eaten. They at least have a purgative effect similar to that of the castor bean, to which the wood-oil tree is botanically distantly related.

"The value of this tree lies in the fact that the nuts contain one of the best drying oils, called wood or tung oil. In recent years this oil has revolutionised the varnish industry of the United States, for it has made possible the manufacture of a quick-drying varnish that is less liable to crack than that made from kauri gum. Tung oil has also been found of special value in waterproof priming for cement."

The bulletin then discusses cultural methods, probable cost of land and labour in the United States, and estimated yield, and continues:—

"In starting an oriental industry in America the most important factor to be considered is the amount of hand labour involved. There does not appear to be much involved in this industry, as the gathering and husking of the fruits seem to be the only handwork required. Further, the American farmer has the advantage over the Chinese of cheap, accessible lands and team labour. Since the hand labour required in a well-planned orchard is not great, it would seem to be entirely possible, by the systematising of such an industry on large plantations, to produce wood-oil more cheaply in the United States than it is now produced by the wayside plantings in China, which must be very wasteful of human labour.

"The prospects are that there will be a continual and growing demand for wood-oil. The increased use of soya-bean oil, it is reported, will tend to augment, rather than to diminish, the consumption of wood-oil, as soya-bean oil dries too slowly, and requires the addition of wood-oil to help it dry. The home demand in China is likely to expand, and the opinion of American importers of the Chinese product seems to be that the American-made oil could meet the requirements of the United States market. If it does, 40,000 acres of trees would be required to supply the present demand.

DEVELOPMENT OF NEW PROCESS FOR UTILISING PETROLEUM RESIDUES.

One of the notable features in the current general expansion of American chemical industries is the evolution of the Rittman process for transforming a large proportion of the residues of petroleum refineries into gasoline, benzene, and toluene. According to a report by Mr. T. H. Norton, United States Commercial Agent, the process, originated in the Bureau of Mines and elaborated as an industrial method under the auspices of the same Bureau, has now issued from the experimental stage and taken its position as a recognised industrial asset in the national cycle of productive activity. By its aid vast quantities of petroleum waste, hitherto available for little beyond fuel purposes, can be transformed at will either into gasoline for use in motor engines or into benzene and toluene, also susceptible of the same utilisation, but constituting likewise the crude material for the manufacture of the two coal-tar high explosives, picric acid and trinitrotoluene, and forming also the starting points for the synthesis of an almost endless variety of dyestuffs, medicinals, photographic chemicals, artificial flavours, and perfumes.

Under normal conditions in times of peace the by-products of American coke ovens can more than meet the national demands in the manufacture of the latter categories of chemicals. The case is, however, far different in regard to the supply of motor fuel. Apprehension is felt that at an early date the supply of gasoline from crude petroleum, or of benzene and toluene from the distillation of coal, may fall far behind the world's demand for motor fuel. The Rittman process promises to relieve entirely this anxiety, or, at least, postpone all danger of a shortage to a very distant date. Economically it will act as a healthful check upon any unnatural tendency to increase the price of ordinary gasoline. The process, as now perfected, makes it possible to produce gasoline at a cost of 6 cents (3*d.*) per gallon. This figure may be contrasted with the wholesale rate of 22 cents (11*d.*) per gallon for gasoline obtained directly from petroleum refineries.

The process is thoroughly protected by patents. Manufacture in the United States is permitted without payment of licence fees or royalties. Manufacture abroad is permissible under the patent rights secured in the different countries on the payment of fixed licence fees. The

American company controlling the patents is actively engaged in introducing this new and distinctly American process in the leading foreign countries, where its advent is warmly welcomed.

There is, it is added, every indication that, at an early date, the American Rittman process will be well installed in all lands where petroleum refineries exist, and will exert a widespread influence upon the rapid evolution of all phases of transportation—terrestrial, aerial and marine—dependent upon an abundant supply of gasoline.

INDIA'S SHARE IN THE RICE TRADE OF THE WORLD.

The *Bulletin of the Imperial Institute* contains an article on the production and uses of rice. Practically all the rice-producing countries of the world are considered separately, in respect both of their rice crops and of their trade in rice, and an attempt is made to arrive at some idea of the world's production of this important foodstuff. It is calculated that the output of cleaned rice in 1916–17, in all countries except China, amounted to about 60,000,000 tons. Of this the British Empire produced about 36,000,000 tons, mostly in India, where the crop (including an allowance of a million tons for native States) was no less than 35,000,000 tons. Of the foreign production of 24,000,000 tons, over 20,000,000 tons were grown in five countries — Japan, Netherlands East Indies (chiefly Java), French Indo-China, Siam, and Korea. Estimates of production in China are largely guesswork, but the Imperial Institute, adopting the view that the output in China is not likely to be much inferior to the Indian crop and may exceed it, concludes that 40 per cent., or a little less, would be a fair allowance for India's proportion of the world's annual production of rice.

No less important is the position which India occupies in the world's rice trade as a source of supply for other countries. That is not a necessary consequence of its importance as a rice producer. Some of the countries of largest production—China, Japan, Netherlands East Indies—do not grow enough to supply their own needs, though in the case of Japan the large increase in the rice crops in the last three years has changed a heavy import balance into an export balance, so far as the trade with foreign countries (excluding Korea and Formosa) is concerned.

The world's export trade in rice is practically under the control of three countries, India, French Indo-China, and Siam. It has been calculated that the quantity of rice which entered into international trade, as shown by the export returns of different countries, amounted in 1913 to about 6,400,000 tons. This includes exports from European countries of rice which has been milled in those countries, which came originally from India, Siam or Indo-China, and which unduly swells the total by being counted twice over. Even so, the original exports of rice from India amounted to 40 per cent. of the total, while those from Indo-China were 20 per cent., and those from Siam 18 per cent.; in other words, these three countries provided nearly four-fifths of the total.

India's export trade in rice is really dependent on Burma. Not only does Burma provide about three-fourths of the exports of rice from India as a whole (1,835,000 tons out of 2,420,000 tons in 1913–14), but Burma usually sends to other provinces of India more rice than those other provinces export. Without Burma, India would not be self-supporting in rice. As it is, India's exports of rice in the year before the war were equal to the gross requirements of the rest of the Empire, though actually only 42·6 per cent. of the exports went to British countries, and 57·4 per cent. to foreign countries.

The exports direct to the United Kingdom were only between 6 and 7 per cent. of the total. On the other hand, the United Kingdom imported considerable quantities of rice from Holland and Germany which had been first exported from India to those countries, and after being milled and polished there had been re-exported to the United Kingdom.

Rice-milling, at one time a flourishing industry in the United Kingdom, had declined before the war owing to severe competition from the Dutch and German mills, with the result that not only was the British home market partly supplied by foreign-milled rice, but what was at one time the considerable British export trade in fully-milled rice had been reduced in many directions. Since the war both the home and export trade in milled rice have been largely recovered by the British rice-millers, and it is hoped that this industry and trade may be retained after the war. The possibilities of the development of the complete milling of rice in India before export are also a matter for consideration.

The second part of the article deals with the uses of rice both as an article of food and for industrial purposes; the value of rice meal as a feeding-stuff for livestock is also discussed. The milling processes are described, and the different grades of rice and the by-products which are obtained are shown in diagrammatic form. Numerous composition tables are given, and comparisons are afforded in this respect between rice and its by-products and other foodstuffs.

In connection with this subject it may be pointed out that the Indian Committee of the Imperial Institute is now conducting, at the request of the Secretary of State for India, an inquiry into the possibility of increasing the use

of Indian raw materials and foodstuffs within the Empire. The inquiry naturally involves an investigation of the extent to which other countries, and especially enemy countries before the war, had secured a predominant share in Indian trade, and the causes which led to this condition.

A special committee has investigated the trade in rice, and it is understood has now almost completed its work. The need for such an inquiry is clear from the facts mentioned above regarding the dominant position taken in the rice trade by Germany and Holland, before the war, as compared with the United Kingdom.

ARTS AND CRAFTS.

Serbo-Croatian Art at the Grafton Gallery.—The exhibition of Serbo-Croat art at the Grafton Galleries is interesting from many different standpoints; but if its attraction is in some measure political, its appeal as an exhibition is primarily from the side of art; and though the art in the first three rooms happens to be represented by sculpture and painting, and only the long room is given up to arts and crafts, the whole gallery may well be described as devoted, in the widest sense of the term, to decorative art. The sculpture claims notice in the first place. The collection exhibited at the Victoria and Albert Museum in 1915 proved that, however much critics might disagree concerning the value of the works of Ivan Mestrovic, there was no doubt that his whole outlook on art was intensely decorative. There is in the present collection nothing in the way of purely decorative work which compares with the roundel commemorating Kossovo, or some of the large vases which were shown in the earlier exhibition, though the plaster cast of the shield for the Crown Prince of Serbia is a fine work of its kind; but there is a far larger proportion than at South Kensington of reliefs in plaster and wood, and it is this work which is of peculiar interest from the decorative point of view. Not only are certain of the exhibits, such as the two angels' heads—one of which stands on each side of the rather painful wooden statue of the Crucifixion—beautiful in feeling and decorative in handling, but the technique is worth the consideration of all those who have to do with sculpture in wood. The treatment is flat and conventional, there is no undercutting, the whole thing is characterised by an extreme simplicity, and the result in most instances is something really remarkable. There are, it is true, cases in which the tool marks seem to have been unnecessarily and unduly accentuated, so as to produce a mottled effect not unlike the punching in certain types of Western European work, which is not wholly pleasing. Further, if the style of the great Serbo-Croat sculptor were consciously imitated by British artists, it would probably lead to disastrous results; but for all that there is a great deal to be learnt from him by those who have the seeing eye. The work of T. Rosandic, the only other sculptor who exhibits, suggests that he is a pupil of Mestrovic, or at least a disciple. It shows no signs of real independence and originality. He exhibits, besides a collection of larger pieces, one or two specimens of jewellery, but there is nothing very remarkable about them. The paintings are all by Racki, and for all their grim realism they are, especially those which illustrate Serbian legends, conceived in a truly decorative spirit. The grouping of the figures, the distribution of the masses, and so forth, strike one at once, long before one is near enough really to understand the subject. The decorative objects in the last room include some beautiful Bosnian damascening, which recalls some of the work from Bosnia-Herzegovina, shown at the Paris Exhibition of 1900, and some remarkable jewellery from Bocche di Cattaro, lent by Sir Arthur Evans. Among the objects for sale are a quantity of dolls, beautifully dressed in the national costumes of the various parts of the Balkan Peninsula and specimens of the work done by the Serbian refugees in Corsica. The embroidery is, as usual, very characteristic—most of it obvious Slav work, with dashes of something which makes us remember the constant neighbourhood of the Turk in the native lands of the workers. There is also a little basket work and some leather work in the shape of slippers, with fronts of cut leather of various colours, such as are worn by the peasants. The exhibition will be open until December 22nd, and it is an event which no one interested in art or arts and crafts can afford to miss.

Messrs. Ramsden and Carr's Exhibition.—The exhibition of the works of Messrs. Omar Ramsden and Alwyn Carr—held annually at this time of the year in St. Dunstan's Studio, Seymour Place, Fulham Road—has for many years past been one of the most important shows of silversmiths' work held regularly in London, and although since the early days of the war Mr. Carr has been in France, and though one hardly expects much work of this kind to be done nowadays, Mr. Ramsden had managed to get together quite a big collection of work this year at the beginning of December. There were not, of course, so many large and important objects as used to be on view in pre-war days, but there was a goodly collection of work none the less. One of the finest pieces was a loving cup, very simple in its main lines, and depending mainly upon its shape for its distinction, but with richly ornamented bands on the stem and round the cover. Another outstanding work was a cup designed as a trophy for a lambing competition. The most imposing piece of ecclesiastical silver work was a large chalice for Winchester College Mission, and there were also some copper and brass almsdishes, vases, and ewers, which were well worth attention, and a couple of well-shaped, spaced and well-lettered

designs for memorial brasses. Amongst the domestic objects may be noted an extremely practical and well-portioned circular dish for *hors d'œuvres*, or cheese and butter—planned to hold three glass dishes, and furnished with a broad flat handle, easy to grasp and good to look upon. Nothing could be simpler in design, but the simplicity was that of a real work of art. A cream (or should we say nowadays, milk?) jug, with a very deep lip and a well-arranged handle, was another happy combination of practicality and art. But, indeed, all the exhibits were, as usual, characterised no less by workmanlike than by artistic qualities. That, of course, should always be the case, but unfortunately objects intended for common use which are labelled "artistic" are too often by no means well fitted for the purpose to which they are supposed to be put, and one is proportionately grateful to find work which, like this, is not only beautiful and decorative, but eminently fit for its purpose.

CORRESPONDENCE.

TECHNICAL TRAINING FOR DISABLED SOLDIERS AND SAILORS.

I receive a large number of letters and inquiries from County and Local War Pensions Committees outside London, which prove that there is not sufficient information to hand as regards the training of disabled soldiers, especially in connection with the proper selection of men for suitable trades; there seems to be a lack of suitable panels of employers and workmen to advise those Committees as to selection of men, and information as to whether certain trades will be willing and able to employ the men when they are trained. Unless something more is done, there may be danger that these men may not find employment in the industry for which they have been trained. As an instance of careful selection of men for particular trades, I may mention the case of a man who was recommended for printing. On interviewing the man, I found his reason for choosing that trade was, that he had before the war been a platen hand in a printer's, and for that reason believed he should take up machine printing, of which he really knew nothing. On further questioning him, I found that a doctor had told him he should take up some occupation which would bring him more or less in the open air. Machine printing was an undesirable occupation for him for that reason alone, because the atmosphere of a machine room is close and confined. Moreover, he had an injury to his leg which rendered him not sufficiently strong for the heavy work and continued standing. I recommended him to take up carpentry and joinery, for this would be lighter and give him chances of going from job to job in a better atmosphere.

I agree with what Major Tudor Craig said about the importance of keeping men as far as possible from taking up fresh trades if they can be kept in their own trade, especially with a little extra training, and give the following as recent examples which have come under me personally:—

Two engineering men, unable to follow their trade because of their disability, were sent to be trained as dental mechanics. They were both intelligent men with good workshop experience, and I advised them to train for the engineering drawing office, for which they would be well fitted after the training which we are now giving them.

Further, I am in accord with what Mr. Myers said about the advantage the soldiers at Roehampton have by the stimulating effect of a number of men training together. I therefore feel that the County and Local War Pensions Committees near London should co-operate, and seek to obtain training for men in London institutions, in order that a fairly large number of men may be trained together for a particular trade. This will have a stimulating influence on the men, and would decrease the cost per man for training.

Lastly, a word on broad training. We must guard against the great danger of narrow training, and not be led away by war-condition demand for men who with short training can now find employment. The men must receive broad and efficient training so that they can hold their own in peace time and be able to adapt themselves to changing conditions of industry. For example, I am asked to train men for acetylene welding, for which there is a great demand now, but such training alone would probably be insufficient and inadvisable from the point of view of stable employment in peace time. The men should be trained in some branch of metal-working, in addition to acetylene welding, if they are to be able to earn their living. They will then become better acetylene welders. Broad and sound training must be the motto, especially for fitting the disabled soldier to hold his own in the future.

C. T. Millis, Principal.

Borough Polytechnic Institute,
December 14th, 1917.

I regret that I was unable to remain for the discussion on Lord Charnwood's interesting paper on Wednesday last, as, if the opportunity had been afforded, I should like to have drawn attention to the excellent work being done by the Canadian Hospitals Commission for disabled and invalided men returning to Canada. That work so commended itself to Sir Rider Haggard, on the occasion of his visit to Canada early last year, that he characterised it as "an example to the Empire." At that time, however, the Commission had scarcely got into definite shape, but its scheme of work was so good, and its plans so well formed, that Sir Rider was satisfied it would be, as it has since proved, a great success.

There are various features of interest in the work of the Commission to which it would be well for our home authorities to give attention, as the experience gained in Canada may be of considerable value to us here. But the one that I have

specially in view is that which formed the subject of Lord Charnwood's paper. In an address delivered at the National Conference of Social Work held at Pittsburgh, U.S.A., recently, the Secretary of the Commission (Mr. E. H. Scammell) said "it was early recognised that the provision of hospitals and homes was not the whole duty of Canada to her men coming back from the war—that they needed work and training." To give effect to this idea, vocational training or re-education classes have been started in all convalescent hospitals and homes, at which the rudiments of shorthand and typewriting, mechanical drawing, woodworking, gardening, poultry-keeping, motor engineering, and a large number of other subjects, are taught. For the necessary instructional purposes, vocational officers have been appointed and Disabled Soldiers Training Boards have been established. On this subject, the reports of the vocational officers of the various provinces concerning the work done from April 1st, 1916 to May 1st, 1917, given in the last report of the Commission, are well worth studying by our own educational and hospital authorities. "Vocational training in the hospitals is necessary," according to the experience of the Commission, "not only because of its educational value but because of its therapeutic value," an opinion fully confirmed by Lord Charnwood and other speakers at the meeting last week.

There is another matter of special interest to us just now, in which the action of the Canadian Hospitals Commission and their experience may be of value; that is the arrangement for finding employment for disabled and discharged men. In all the Canadian provinces, provincial employment commissions have been established, nearly all of which have large numbers of local committees. The result of these appointments has been most gratifying, and may furnish important and useful information to the various ministries of our own Government who are charged with the duty of finding openings for disabled men.

E. T. Scammell.

NOTES ON BOOKS.

Arithmetic for Engineers. By Charles B. Clapham, B.Sc. London: Chapman and Hall. 1916.

Mr. Clapham, in his preface, apologises for his title, and not without reason, for his book goes far beyond the limits usually assigned to arithmetic, and its use need by no means be confined to engineers. However, modesty is an unusual characteristic of authors, specially of authors of school books, so there is not much fault to be found with the title, and still less with the contents of a very useful and practical text-book.

The only previous knowledge the author assumes in his readers is a knowledge of the first four rules of arithmetic, and if any students are to be found who lack the necessary information they need not be discouraged, for they will find all they want in the book itself.

The characteristic of the book is that the author throughout deals with concrete things, not merely with numbers; and even the simplest propositions are expressed graphically. Thus to explain a vulgar fraction he gives us a diagram of a unit divided into parts, so that you can see for yourself that $\frac{3}{4}$ means three of the four parts, and $\frac{13}{23}$ means thirteen of the twenty-three parts into which the unit is divided. In like manner it is graphically shown that $\frac{3}{4}$ (of a unit) is really the result of dividing three units by four units. And so throughout the book the student is led to think not of ideal numbers, but of actual concrete volumes and magnitudes.

After two chapters on vulgar and decimal fractions, Mr. Clapham leaves arithmetic pure and simple, and goes into algebra, for his three chapters—"Symbols and their Uses," "Simple Equations," and "Transposition of Formulæ"—are frankly algebraic and nothing else. But the algebra is treated in a very unusual fashion. Put roughly, it may be said that Mr. Clapham tells his students that a vast number of mathematical calculations may be simply carried out by the use of symbols and formulæ which do not necessarily require translation until the result is attained. The statement in this shape (which is not to be fathered on the author) is an obvious platitude, but to many youthful students of algebra it must be a revelation. At all events, Mr. Clapham's method is wonderfully clear and simple, and to most people it will certainly be novel.

The chapter on Logarithms is very clear, but there is not much room here for any novelty of treatment.

Mensuration is treated at considerable length, and this is the only part of the book really devoted to purely engineering subjects. The chapter on "Graphs" also is mainly engineering, but the instructions in diagram making, and on the uses of squared paper, appeal to others besides engineering draughtsmen.

The final chapter, on the "Slide Rule," is excellent. It contains just the information required by a student who has to rely on private study, and the clear detailed instructions for the practical manipulation of the rule are enough to enable any intelligent person to use one without further help.

H. T. W.

Cotton and other Vegetable Fibres: their Production and Utilisation. By Ernest Goulding, D.Sc., F.I.C. London: John Murray. 6s. net.

Among the many lessons which have been taught us by the war, few have been more important than the necessity of drawing the raw materials for our

textile industries to a larger extent than was the case before 1914 from countries within the Empire. The question of increasing our sources of supply will, no doubt, receive attention when the various problems of reconstruction come to be considered; and it is in view of this that Dr. Goulding has prepared the present volume, which gives in a very handy form a summary of the position and prospects of the world's production and utilisation of fibres. The volume, it should be mentioned, forms one of the Imperial Institute series of Handbooks to the Commercial Resources of the Tropics.

The lion's share of the book is naturally devoted to cotton, the raw material of the greatest manufacturing industry in the British Isles. According to the Census of Production of 1907, the total value of the cotton yarn produced in that year amounted to some £96,000,000, and that of cotton piece goods to about £82,000,000, while the number of persons directly employed in the industry was returned as 572,869.

Dr. Goulding gives an excellent description of the cotton plant and its products, the structure of its fibre, the methods of its cultivation and of its preparation for the market. He also deals with the production of cotton in the principal countries and the chief commercial varieties, while a further chapter is devoted to cotton-growing in British West Africa, and other parts of the British Empire. In this connection it is interesting to note that the quantity grown in Uganda rose from 21,566 lb. in 1904 to 13,126,587 lb. in 1914, while that grown in Nyasaland similarly rose from 692 lb. in 1902 to 3,065,248 lb. in 1915.

The other fibres described are flax, hemp, ramie, jute and kindred fibres, and various cordage fibres, while the last chapter treats of a number of miscellaneous fibres, such as pineapple, coir, piassava, kitool, raffia, etc. The book is illustrated by twenty very good photographs.

THE YEAR-BOOK OF THE UNIVERSITIES OF THE EMPIRE, 1916 AND 1917. Herbert Jenkins, Ltd. 7*s*. 6*d*. net.

The compilation of this year-book is one of the outcomes of the Congress of the Universities of the Empire, which was held in London in 1912. It contains, separately for each university, lists of the professors, lecturers, and other members of the staffs, information concerning conditions of entrance, length of terms, courses of study, scholarships, residential facilities, etc., and a summary of events for the preceding year. The universities dealt with are no fewer than fifty-three, and the year-book contains an immense amount of information set forth in a clear and concise manner. It gives rather fuller particulars concerning the universities dealt with than *Minerva*, admirable though that publication used to be, and it will certainly be more gratifying to the Briton in search of information concerning the universities of South Africa to find what he wants under the heading "Cape of Good Hope" than to turn up "Cape Town" and find himself referred to "Kapstadt."

GENERAL NOTES.

STATE INDUSTRIES, BANGANAPALLE.—Mr. M. H. P. Ghatalah has sent to the Society a counterpane woven at the State Weaving and Dyeing Factory of Banganapalle, Madras Presidency, where he is Superintendent of Industries. The factory has been started recently with the object of finding work for the illiterate unemployed. Such men were entertained and trained in the arts of weaving and dyeing. During the period of their training they received a small percentage more than they actually earned by the work they turned out, and now many of them are self-supporting. A "home industry" has also been introduced by lending looms to widows and "Gosha" women, *i.e.* Mohammedan women who are not allowed by their customs to move about in public. Such women were, in many cases, left in a most helpless condition; but they are now engaged in a healthy occupation, and are saved from much privation and misery. Yarn is issued to them, and the carpets which they weave are received into the factory after the women have received a fixed wage for the work done. In addition to this, sericulture and lac cultivation are also being conducted under State supervision.

OVERSEA TRADE AFTER THE WAR.—H.M. Trade Commissioner in South Africa, Mr. U. G. Wickham, in his report for 1915-1916 advises all who intend to interest themselves in that market, when munitions are no longer wanted, to make up their minds that the time for action is *now*. "No doubt they are not, and will not for a while longer, be able to deliver their goods, or even to show catalogues and prices. There is, however, very much that they can do and ought to do." He points out that people at a distance have difficulty in obtaining information as to what is being made for war purposes which has a permanent value as a commercial requisite for civilian use after the war; as to what British manufacturers have learnt to make since the outbreak of war and as to what they can make, are making, or intend to make of the many things wanted in South Africa and at present unobtainable, or being procured from foreign sources. He recently issued a series of circulars broadcast to importers in South Africa inviting advice and criticism, and he says: "I do not care to estimate the number of replies which—with or without concrete instances of past conservatism—reiterate the message, 'Tell the British manufacturer to make what we ask for, and not what he thinks we ought to ask for; tell him that if he does not do so, sentiment or no sentiment, we shall do as we did before, and buy elsewhere.'"

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, DECEMBER 28, 1917.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 2nd, 3 p.m. (Juvenile Lecture.) P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, "Animal Camouflage."

The lecture will be fully illustrated with lantern-slides.

Special tickets are required for the Juvenile Lectures, and no person can be admitted without one. A few tickets are still left, and these will be issued to Fellows who apply for them at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and can be obtained by Fellows on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, December 13th, 1917; THE RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, in the chair.

THE CHAIRMAN (Lord Islington), in opening the meeting, said India's trade relations with other parts of the world had been rudely shaken and interrupted by the great world conflict, and it was very appropriate that before the termination of the war careful consideration should be given to the methods by which in future those relations might be renewed, strengthened and improved. The future would demand organisation based on forethought and knowledge to a very much greater extent than had hitherto been the case. With the diversion of trade that must inevitably take place as a result of the war, new openings would arise and new channels would have to be found. Mr. Chadwick would deal in his paper with three countries—Russia, France, and Italy—from first-hand knowledge obtained on the spot. The war had emphasised to a singular degree the importance of tropical produce in the world's economy. A very large and general demand for those products was expected to arise immediately on the termination of hostilities. It would be well known to all those present that India had played a very large and immensely important part in meeting the needs of the Allies with regard to a great many essentials, such as jute, oil seeds, hides, and wheat. It must be fully realised that the competition that prevailed before the war would in no way be abated when the ordinary conditions of interchange of trade once more revived. In the past India's position as a trading country had been pre-eminent, and with energy, scientific organisation and foresight there was no reason why in the future she should not continue to hold that position in the great rivalry that would ensue in the days to come. Mr. Chadwick formed part of a mission that was appointed by the Government of India, to study trade conditions with Russia, France and Italy. The mission received a very hearty welcome in all the countries it visited, and indeed it went to some of those countries in response to a cordial invitation from business men in the chief cities. These invitations, he thought, showed a desire on the part of our Allies to develop trade with the British Empire, and especially with India, a desire to which a most energetic response should be given. They also showed that merchants actually engaged in Indian trade, who, when circumstances permitted, visited those countries, did so definitely to establish trade between them. He hoped that the precedent established by the mission would undergo considerable extension, and that a wide interchange on the part of business men in the respective countries would take place, with a view to developing various branches of trade. Since Mr. Chadwick's return from Italy he had been appointed, under the Government of India, as Indian Trade Commissioner in London. Undoubtedly the duties of that post were going to be of the very first importance in the immediate future,

because they comprised the establishing and organising in the City of an Indian Trade and Commercial Bureau. The staff and equipment were in a state of well-matured development, and he confidently anticipated that the Bureau would render a very great service to traders in this country, to traders in India, and to those who were engaged in the production of various raw materials throughout that great Empire. He would like to make a plea that Mr. Chadwick should receive—as he was sure he would receive—the most cordial support and assistance from all in this country connected with businesses and products in India. However well endowed Mr. Chadwick might be himself — his career in India had been most useful and energetic—his work would avail but little if he did not receive that co-operation. In the task to which Mr. Chadwick had to address himself he would find other sources of assistance of the very first value in bringing him into contact with groups of trading firms interested in the raw materials which were the foundations of their industries, and he would especially commend to his favourable attention, as a great adjunct to his work in the future, the help that could be rendered to him by the Imperial Institute. From the various trade committees, Indian committees, and committees of business men that assembled in the Imperial Institute, Mr. Chadwick could obtain first-hand and up-to-date information with regard to the intrinsic merits of the various raw products used for commercial purposes, and he would find the Institute and its staff ready and willing to render him very valuable assistance. With regard to the three countries with which the paper dealt—Russia, France, and Italy—although one of those countries was now under the shadow of a great ordeal, it might be confidently hoped that, when anarchy had made way once more for law and order, Russia and its people would form a great centre of trading industry, with which, he trusted, India and other parts of the Empire would come into the closest contact at no very distant date. With respect to France, its trade with India was an old-established one of the greatest value, and the fact that the British Empire and France had fought side by side for the past three and a half years to maintain the great principles that underlay the objective of this war would be a great incentive to the furtherance of peaceful relations with France, and the same might be said of Italy. He hoped that after the war the trade policy of the British Empire would be free from all vindictiveness in any part of the world, and that it would be characterised by a broad-minded tolerance even to those hitherto our enemies. He believed that that tolerance could, with ordinary prudence, common sense and foresight, be consistent with ensuring conditions of Imperial security. The British Empire to-day abounded to an almost unparalleled degree in all the raw products that were the basis of the great industries of the world, and some of those raw materials were necessary for the manufacture of articles upon which the safety of the Empire depended. Speaking in no vindictive spirit but in a tolerant spirit of common sense, he ventured to say that the Empire must organise its system of trade in the future, so as to ensure that its raw materials are manufactured within the Empire and not in enemy countries. Therein lay our power as a great Empire. It was an incalculable power if only we made use of it, and he ventured to say that we must make use of it. Our Imperial raw materials must no longer be the prime instrument—in some cases the exclusive instrument—of German trade and industry, but must form the basis, first and foremost, of our own industries, whether those industries were established at home, in our Dominions, in our Colonies, or in India. He hoped that as time went on those industries would be established firmly and would flourish in all parts of the British Empire.

The chair was then vacated by LORD ISLINGTON, who had to attend a Cabinet Committee meeting, and was taken for the remainder of the proceedings by SIR CHARLES C. MCLEOD.

The paper read was—

THE TRADE OF INDIA WITH RUSSIA, FRANCE, AND ITALY.

By D. T. CHADWICK, I.C.S.,
Indian Trade Commissioner.

It is usually considered to be a mistake to begin with an explanation; but I feel that an explanation for distributing sets of tables is due from me. When endeavouring to present a picture of the course of trade between two countries, it is impossible to avoid statistics altogether; and statistics are the bane of a paper. Therefore, the Secretary has kindly distributed them, so that the authorities on which are based many of the statements I shall make can be readily seen, and also that mere figures may be cut out of this paper as much as possible. The tables are taken from the official publications of the different countries, or are directly based upon them. It is not safe to press too closely comparisons between these returns, because the method of compilation and classification varies somewhat between different countries. Bearing this in mind, I would ask, before dealing directly with the trade of India with Russia, France, and Italy, to refer to a few large features of Indian trade—commonplaces probably to many in this room—which are worth restating from time to time, especially in England.

The growth of India's total foreign trade has been especially rapid since the beginning of this century, and exports of merchandise have always exceeded imports. India, judged by the total

value of its foreign trade, stands high among the countries of the world. It is only surpassed by five countries in Europe, and outside Europe by the United States (Table I.). But the course of its trade differs very considerably from that of the other large outlying parts of the British Empire. It would appear from the figures in the *Statesman's Year Book*, that just before the war India obtained from the United Kingdom almost two-thirds of her total imports, whilst the large Colonies got from this country somewhat over a half or a fifth of their requirements. But when one comes to exports from various parts of the Empire, the position is entirely reversed. India finds a market in England for less than a quarter of her exports, whilst Canada, Australasia and South Africa succeed in selling here from half to 90 per cent. of their exports. In other words, whilst India's purchases are mostly made inside the Empire, her sales are mostly made outside the Empire. The importance, therefore, of foreign markets to India's trade is clear, and consequently the importance of these foreign markets to England's sales to India, because imports are paid for by exports.

During these last three years of war a larger proportion has naturally been sent to the United Kingdom, but foreign Continental markets still remain of very great interest to India.

Although the Asiatic markets are very important to India, the European ones are the most valuable. In 1913 foreign countries in Europe took one third of all India's exported goods, and the United Kingdom one quarter; and, curiously enough, India's trade with European foreign countries was practically equally divided between enemy countries and the Allies. Thus, although the channels through which trade will flow after the war are still most obscure, India is obviously very directly interested in the commercial needs and possibilities of the Allies, and, in cases where they have been buying Indian produce through Germany or Austria, in seeing whether direct relations could not be substituted for enemy intervention.

It happened that Mr. Black, who has recently been appointed general manager of the Alliance Bank of Simla, and I were sent on this inquiry first to Russia and then to France and Italy. Conditions, of course, differed widely With France, India had a long-established connection, and a steady trade of about £12 millions a year. With Italy trade before the war had been rapidly developing. With Russia, so far as was generally known in India, trade had on the whole been stationary, and could practically be summed up in the one word "tea." It was impossible, of course, after two years of war, to collect samples of what actually might be required in peace time in the different countries. As one man in Russia said: "In these days, to the man who wants a cat, a black cat is as good as a white one." Of which, probably, the English counterpart is, that the lady who requires sugar does not complain whether loaf or brown sugar is offered. Reliance had thus to be made chiefly on personal interviews with manufacturers and merchants. In all our visits we everywhere received the ready help of our Consuls and British Chambers of Commerce, though the former were often much overburdened with other work. A few had not been in close touch with dealers in raw produce. This was natural; no inquiries had ever hitherto been made to them about these articles, nor had their attention been drawn to Indian trade. In Italy, the Credito Italiano, one of the largest Italian banks, took the greatest interest in our visit, and much trouble and pains to make it useful and profitable. If to-day attention disproportionate to the volume of trade seems to be directed to Italy, it is because Germany had obtained much greater hold there than in France, and because business relations between France and India are older, better established, and stronger than between India and Italy.

Russia.—The main points in regard to Russia can be quickly stated. It is just a year since we were there—*i.e.* before the Revolution. It is difficult to know how far in the meantime internal disorder has damaged the economic future of the country; the time may be long before the course of trade can become stable, and political events in the unknown future may encourage or may gravely delay enterprise; but ultimately the economic needs of a population of 180,000,000, increasing by 2,000,000 a year, must reassert themselves. Thus an examination of the course of Indo-Russian trade before the war has not merely academic interest simply because trade with Russia is temporarily paralysed. Both statistics and personal inquiries showed that in the past Germany had supplied about 50 per cent. of Russia's demands for tropical produce. There is thus trade to be done and organised before the old ties with Germany which have been broken can be reforged.

The extent of German penetration in Russia

almost surpasses the imagination of those who have not been there. In the large towns German and Russian were the language of business—French or English was of little use. Until 1890 German was the language of the Lutheran schools in the Balkan Provinces, and till about the same date there was a German university at Dorpat. Over 10 per cent. of the ordinary commercial and news journals published in Russia before the war were printed in German. We were given to understand that German was obligatory in the commercial schools of Russia. Even British trading houses had in the past given sole agencies for Northern Europe to Hamburg firms. Several Russian banks were organised or developed by German interests; large and compact properties in the towns were owned by Germans; behind all there was a very well-equipped Consular service which Germans used freely. There is no doubt they studied the market and the methods of the Russian. In the process they did not always make themselves loved. As one bank director put it: "The Germans certainly gave you the articles you wanted, but there always came a time when the German tried to do business with his feet on your table."

All this means is, that the Germans were in the towns of Russia. British capital and energy in Russia were mostly directed towards developing the more remote resources of the country, *e.g.* oilfields near the Caspian or mines in Siberia. The development of the natural resources of the remote corners of the world has an irresistible attraction for the spirit of British enterprise and adventure. But it is the men in the towns who are in closest touch with the business life of a country, with its commercial needs and methods, and with its general, financial, and industrial development. It is thus not surprising that Germany quietly gathered to herself as large a share of the trade in tropical produce as that which she had in the trade in manufactured articles India had made little or no sustained effort to develop organised direct connections. British merchants had done something in particular lines, but were completely outnumbered by Germans, and at times employed Germans as their agents.

In thinking of German trade with Russia it is wrong to think of it as confined to trade in manufactured goods.

The Indian statistics give particulars of the goods consigned to a country, and, as far as India knew, Indian trade with Russia outside tea was almost negligible, being only worth about £400,000 a year. Including the tea trade, which had largely been developed by Russian merchants in Calcutta, the total of consignments direct from India to Russia was about £1⅜ millions a year. The Russian returns, however, show that before the war goods known to be of Indian origin to the value of £3⅔ millions reached Russia, and if an estimate be added for those whose identity of origin was lost in transit, due to rehandling or regrading, or polishing, etc., Russia's imports of Indian goods were worth between five and six millions, and covered a variety of articles, although in India we deemed the trade a small one, and one mostly restricted to tea. The figures on which this statement is based, and also the line of argument which shows that this middleman's trade was mostly done by Germany, are given in the tables circulated. It will also be seen that before the war Russia's general import trade was growing rapidly, and especially marked was the growth of her needs for Indian produce. Thus, in spite of the old political mistrust between Russia and India, Indian goods were finding their way into Russia in steadily increasing quantities, and the total volume of this trade was about three times as large as the Indian returns indicated, and for the most part it was done by Germany.

Ample corroboration of the general truth of these statements was obtainable in Russia. Manufacturers and merchants repeatedly told us they had regularly bought Rangoon rice in Hamburg, Indian kips at Leipzig, jute from German houses, and so with pepper, castor, beeswax, etc. One merchant in Moscow went so far as to say, "Yes, you had the goods, but the Germans knew how to sell them"—a sweeping statement which our merchants would certainly not accept, but yet which shows accurately the impression in some business circles in Russia.

Brief mention may be made of the Indian articles in chief demand in Russia. Except perhaps at Warsaw or Lodz, where it can compete with the short-stapled cotton of Trans-Caucasia and Northern Persia, there will be very little demand for Indian cotton. The mills round Moscow use the American variety, and draw most of their supplies from Turkestan, where the crop before the war had reached 1,500,000 bales of American variety. This, by the by, is one of the most successful efforts recently made in the world to extend cotton cultivation in new areas. But this development means a greater demand for jute, which is

required to bale it. Jute was also needed more for general trade purposes, and promised to be in still greater demand. The largest openings seemed to lie with certain foodstuffs, oilseeds, light hides, reagents for soft tannage, medicinal plants, spices, beeswax, lac, and rubber. Russia is always associated in one's mind with tea, which is popular everywhere except in Finland. The consumption, however, is as yet only $1\frac{1}{2}$ lb. a head per annum, as compared, I think, with about 7 lb. in this country. Rice was also advancing largely in favour; but the chief market for Rangoon rice is in North-west and Central Russia. In the south, rice from Persia and Trans-Caucasia, admitted on favourable Customs terms, holds the market. Pepper and spices of all kinds are readily sought for in the towns. In the manufacture of drugs considerable progress has very recently been made, because in the past such manufactures had been stifled by the commercial treaty imposed by Germany on Russia in 1904. This is now void. In oilseeds the position is peculiar. For linseed there is, of course, no need, and for castor an increasing one. But, although Russia is such a large agricultural country, there was a large and growing demand for edible vegetable fats, especially for those made from the better grades of copra. Soap has hitherto been almost exclusively made from tallow. The supply both of this and of the sunflower crop was insufficient for the very rapidly increasing demand for soap. Unfortunately here, however, groundnuts are classified in the Russian tariff as a luxury food, at rates which prohibit their use for industrial purposes. The above are not army demands, but civil ones. Another rapidly increasing civil demand was for long boots with soft uppers—which may also mean reagents for soft tannage such as myrabolams. Even in the villages bast slippers and gaiters were giving way to leather boots; and the towns of Eastern Russia and Western Siberia are very rapidly growing. Several which till recently were villages, have now from 70,000 to 200,000 inhabitants. Lac is in large demand in village industries round Moscow, whilst there is always a big market for scrap rubber for making goloshes, which are widely used by all grades of the community in the towns. The demand for Indian products was thus both varied and growing. Moreover, the articles are not those which cater for luxury trades, susceptible to fickle changes of fashion or to bouts of economy, but consist mainly of staple goods for food, drink or industries, the demand for which, when once established in a town, persists and does not easily disappear.

Last year there was a strong desire in responsible commercial circles in Russia to develop direct trade relations with India on organised and stable lines. Organisation, they said, would be necessary, because trade with Russia could not be built up satisfactorily by correspondence alone. Moreover, competition in Germany's interests would certainly reappear. Further, the largest markets for Indian produce draw their supplies from the Baltic and not from the Black Sea ports, and questions affecting shipping and rates of freight would arise. For instance, we were told that before the war transhipment of goods in Hamburg was much cheaper than at London or Hull, and whilst freights from India to London or Hamburg were nearly the same, freights from London to the Baltic were much higher than from Hamburg to the Baltic. Thus it was much cheaper everyway to ship from India *viâ* Hamburg. It seems also German lines more readily gave through bills of lading to ultimate destination than did British ones. The need for organisation was further emphasised to get to know the actual requirements, methods and changes of the Russian market. British manufacturers in Russia spoke very highly of its stability when once its characteristics were known. Trade connections when once formed were not readily broken. Thus, on account of the need of local knowledge, of the difficulties of the language, of the certainty of questions arising which would affect customs, railways, shipping, and of the probability of German competition reappearing, the greatest stress was laid on joint strong organisation in both India and Russia. Powerful interests in Russia were, and I believe still are, prepared as soon as opportunity permits to co-operate in establishing such joint organisation.

The openings for trade thus promised to be good as soon as political events would permit. It was a market which promised to be both a varied and expanding one, and it was substituting direct trade for one which had hitherto largely passed through German hands. The potentialities still remain.

Russia needs these Indian goods, and will get them. It is surely better to organise that trade direct than leave it to be the foster-child of an enemy country.

France.—The trade from India to France is old established and considerable, viz., about £12 millions a year, and goods in the main go direct between the two countries. Many of

our Indian houses have their own representatives in France, and some of the large French houses have their own branches in India. The general run of our Indian goods is thus well known, and comments turned more on the quality and cleanliness of special articles than on the methods or means of organising trade and commerce. General opinions about the immediate future after the war were for the main part restricted to a wish, frequently expressed, that at least during the period of demobilisation and for some time after, whilst industries are being restarted and stocks replenished, some means would be devised by the Allies jointly to ensure raw materials being directed to Allied countries. No detailed suggestions were made. This was the result of a general appreciation of present actualities; of doubt as to the condition in which Northern France would be found; and of confidence that if only time for recovery was allowed, trade could be restored through the former channels. The self-restraint, patience, and silent determination of France during these three years of trial have won the admiration of the world. Even in the first flush of the news of the German retirement from Noyon, there were no demonstrations or hasty rejoicings. Whilst business men in all towns without exception gave us a very warm welcome, and repeatedly expressed their pleasure that India had sent a small commercial mission to France, the facts of the war were first in their thoughts, and it was not easy to draw from them a detailed forecast of future possibilities. Also the areas which mostly use Indian cotton and linseed were in enemy occupation. A few general features were, however, made clear. As a result of war there has been a large development in the industries of the Rhône Valley, and several of the bigger mills of the north have opened factories here. This will possibly create a new area using some of our Indian goods; and to foster the trade of this tract very large works for extending Marseilles harbour have being pushed on, on which German and Austrian prisoners are being employed.

In new lines of Indian articles there should in all probability be openings hereafter in France for a few articles.

First, hides. Hitherto France has mostly bought Indian skins and has purchased what hides she needed through Germany. The tanning industry has been developed, and is getting into closer touch with the original sources of the raw material. Hides may thus form a new line to France. Jute sacks for Havre, made exactly to specification as to markings and size, may be in demand in spite of the duty, if shipping freights continue high. They are needed for bringing coffee, etc., from Central and South America, and must be exact to description.

In the main, however, it appears that Indian trade with France will follow the former articles with these possible additions, and perhaps tea, which is slowly growing in favour. Indian goods mostly pass into consumption in France, and only a few—*e.g.* pepper and, to a small extent, rice—are re-exported. The scale of import duties has been, and will remain, a large factor in determining the class of Indian goods which enter France. The general effect of these rates appears to be that where supplies from India are not essential for the well-being of a French industry, the goods on entry are subject to duty wherever they compete with products produced in France or in the French colonies. Thus a duty of from 3 to 8 francs per 100 kilos is levied on rice not grown in French colonies, whilst that from Saigon is admitted free. The result is that, except for a few luxury qualities which appeal to a special market, most of the Burmese rice imported into France is re-exported. Over 90 per cent. of that consumed in the country comes from Indo-China. Similarly, pepper not grown in the French colonies pays an extra duty of 104 francs per 100 kilos on entering France. But groundnuts are admitted free, though the best variety on the market comes from French West Africa. The reason apparently is that the supplies from the French colonies are insufficient for the needs of the oil industry in Marseilles, which gets about two-thirds of its supplies of groundnuts from India. More and more attention is being paid in France to the economic development of her tropical colonies, both by improving communications and by testing new crops, and it would seem that in the future India must expect more competition in France from these sources. In view of this possible greater competition in the future the remarks of French dealers on Indian produce are interesting. The manner in which coffee, castor, linseed, rubber, copra, rice, and skins arrived was praised. Other articles were severely condemned, especially hemp, on account of the dust and dirt it contained. Bales of hemp from India and China respectively were opened in our presence and wisps were taken out of the middle and shaken. Less than a minute sufficed to prove ocularly the difference, and the ground of their complaint. Fine dust rose in clouds from the Indian sample, whilst the Chinese one was remarkably clean. Indian

tobacco—*i.e.* the leaf for which there is a market in France—was roundly classed as the worst marketed in the world. If it could be better sorted, approximately graded, and better packed we were assured it would obtain both a wider sale and a better price. Wheat was blamed both for the presence of barley and the frequent mixture of small stones and dust. Consignments have certainly improved in quality but slowly, and whilst Algerian wheat, also grown in the main by small cultivators, was formerly much dirtier, it is now delivered cleaner. Merchants in Marseilles were unanimous in the opinion of a recent fairly steady falling-off in quality of Indian sesamum in recent years. In regard to groundnuts the remarks were partly conflicting. The vast majority said that the machine-shelled nuts were greatly superior to the old hand-shelled ones, which often came damp, wet, and rancid. Others still required the old grade, provided it was not too wet. But these were men who for the most part made the lowest grades of soap, and so required the cheapest article they could procure. The prevailing attitude of the Marseilles market can, however, be best inferred from the action of the dock company. A dock company is not generally supposed to change readily its methods of housing and handling goods; it is usually in a sufficiently strong position, only to move in response to insistent and permanent demands. The practice was to store Coromandel decorticated groundnuts wherever space was available in the docks, either under tarpaulins on the quay or in warehouses. They have now, however, allotted one large dry warehouse for Coromandel dry or machine-shelled nuts, to which these nuts are taken immediately on arrival. This is evidence of a real demand for the better quality, which is also shown by a difference in price for the two articles, both in Marseilles and in India. In fact, this improvement in the handling of groundnuts is probably one of the most successful attempts in India on a large business scale to obtain on the world's market a better price for quality. The ideal machine for decortication has not yet been obtained. Indian shippers may probably be interested to know that on account of the high shipping freights different decorticating machines are being tested in French West Africa, with a view to shipping those nuts also decorticated and not, as hitherto, in shell, which, if they succeed in finding a better machine than we use, means increased competition for our produce. The objection to the machine most used at present in India is that many of the nuts are broken in passing through it. In the old days some of our shipments had been beyond description. The nuts had arrived as a black, putrid, rancid mess which had to be literally hacked out of the hold of the ship. This is, of course, hopeless. The 1912 crop from India had been a very bad one, and though recent ones have been better, the opinion was that there was room for considerable improvement in quality, as our nuts often yielded 4 per cent. less oil than the African ones. In Lyons regrets were expressed over the decay of Indian silk, chiefly because the silk that formerly came from Bengal took a very high polish; it was, for instance, specially prized for the old top hat so beloved of a former generation. The silk manufacturers, however, seemed to despair of any revival of the Indian industry. That which now came forward was so badly reeled and prepared as to be unsuitable for weaving. These strictures did not apply to the silk of Kashmir, which was always well spoken of. Lac was blamed in Paris for its packing. The boxes were irregular in shape, size, and contents, and often not strong, leading to wastage, and loss of time and labour in handling and distribution.

On the whole, though at first after the war there is bound to be a large demand in France for those lines of Indian produce which she was formerly taking—and possibly, in addition, a permanent one, hides, and a more temporary one for jute sacks—it seems doubtful whether the French market will become a more varied one, capable of absorbing articles hitherto sent to Germany. Our manufactured goods, such as jute sacking, tanned skins, and oils have to bear duties, and some of our raw materials which compete with the produce of French colonies do the same. It is a market in which there is likely to be greater competition in the long run, and in which we shall only maintain our position by constant attention to quality, purity, and cleanliness.

Italy.—Italy, after France and Russia, seemed the most buoyant of the three. It certainly seemed the youngest; although among the oldest countries of the world they claim the merits and failings of youth, having that faith, energy and interest in the future which is associated with youth, and feeling acutely and obviously both success and disappointment. It has been no small work to weld together and develop the Italian national sense and national confidence. For, in spite of recent disasters, there is a very marked and distinct national pride and consciousness in Italy. It was largely this realisation

of nationality which drew Italy into the war. For it was the people who forced Italy into the war. The story of how they compelled an almost reluctant Parliament to action is a dramatic one, and can be read in several books. It is well to remember that Italy freed the French frontier in the first days of war, though Bismarck is credited with saying that it was sufficient for him that an Italian corporal with a flag and a drum faced to the west and not to the east. For Italy this is a war of ideals and realities, not one merely to recover the Irridenta, but to end Austrian and German domination under which she has laboured for years. As Mr. Sidney Low says: "Few foreigners before the war knew how far the German financial subjugation of Italy had gone; nor do they see it now in all its significance unless they read such books as those of Preziosi and Henri Hauser, in which the details of this amazing story are given." I must admit that Preziosi's book appears to an Englishman unacquainted with previous conditions as a somewhat violent production. Hauser's book is translated into English under the title "Germany's Commercial Grip of the World." German interests had penetrated in Italy into banking, shipping, industry and trade, and although the Italians admit that they have learnt much from German organisation, etc., a very large number see that their whole economic independence was threatened, and it was not for this that the battles of the sixties were fought, or the hard times which followed lived through. They want to live and let live, and to develop in friendly equality with other nations. In this Britain, through her long and traditional friendship with Italy, possesses both a powerful political and practical advantage. The complaint against the British is that they have too persistently regarded Italy as a land of art, sunshine and scenery, and been blind to her economic and industrial development. I have nothing to do with the political questions, but the interest to India of seeing Italy independent and strong, developing on friendly terms with the British Empire, seems obvious to any one who looks at a map. And the trade between India and Italy in both directions is greater, and seems to possess greater possibilities, than that between Italy and any other part of the Empire.

India's exports to Italy before the war were worth about five millions a year, and consisted almost entirely of raw materials for industries, such as cotton, jute, hides, oilseeds. The only foodstuffs taken in any quantity were wheat and pepper. There is not much scope for introducing new articles of food and drink from India, for Italy grows her own rice, does not drink tea, and prefers the cheaper South American coffee. It is in the development of her industries that the chief market for the future will lie, and the progress made here is remarkable. At the outset, as a manufacturing country, Italy had three great difficulties to contend with—viz., lack of capital, lack of industrial experience, and practically a complete lack of coal and iron. She had, and has, an abundant population. Before the war emigration averaged 680,000 a year, chiefly to the Argentine and America. Where the Italian colonies have settled both in America and the Levant, Italian export trade has developed and grown. In the last twenty years much attention has been paid to banking organisation, and the two largest Italian banks have their own branches in London. There are three large banks, with capital between £2¾ and £6¼ millions. Deposits and current accounts, which in 1912 were £52 millions, were £133 millions at the end of April, 1917. The lack of coal was the most serious material disability, but this has largely been surmounted by the development of hydro-electric installations, which already yield for industry more horse-power than the imports of coal, though the latter were 10,000,000 tons a year. The opportunities for extending the erection of such electric installations are by no means exhausted, and in such development Italy sees a chance of ensuring her own supplies of cheap power. Industrial experience has been obtained in North Italy. The results of all this is, that in the last thirty-five years the value of Italy's imports have trebled, that of her exports have doubled, whilst the trade in fully-manufactured articles had, just before the war, almost attained equilibrium. In passing, it may be noticed that in the same period, in spite of the increased trade and the wider trade relations of Italy, Germany had both, in the import and export trade, risen from sixth to first in importance among Italy's suppliers and markets; and whilst two-thirds of what Germany sold to Italy consisted of fully-manufactured goods, nearly two-thirds of what she bought were articles needed for industry, either raw or partly manufactured. In contrast to this, over half of Britain's sales to Italy were raw materials, mostly coal, whilst nearly half of Britain's purchases were fully manufactured articles—mostly silk. But an industry which

has thus surmounted its earliest difficulties would seem to possess the elements of stability, vitality and promise of progress.

Capital is still needed in the country, schemes for further utilisation of electric power have yet to be carried out; but results already obtained hold out promise for future development. During the war many industries have been able to improve their financial reserves; between the outbreak of war and the end of 1916 new capital up to forty millions had been devoted to industrial companies, and many gaps in Italian industry had been filled. Further, Italian industries have escaped the ravages of war which have fallen so heavily on France, and it is hoped will be, in the main, in running order when peace arrives. Stocks of industrial raw materials are low. Thus after the war an increased and more varied demand for raw materials may reasonably be expected from Italy. Whilst touching on these general features, it is of importance to note that the financial policy followed by the Italian Government in raising its war loans is similar to ours, in that provision has so far been made for meeting new interest charges by increased taxation.

Further, Italy promises to offer an alternative market to some extent to Germany for several of India's products, notably in cotton and hides, and perhaps in oilseeds. The Italian cotton-mills already use a greater proportion—viz., one-fifth of the total raw cotton imported—of Indian cotton than does any of the other large European countries. Their machinery is largely adapted for using lower counts. It is a warm country, and cotton goods are more widely used for clothing than in Northern Europe. Owing to the cost of articles after the war, it is likely that the home demand will turn more to the cheaper class of goods, and in addition Italy will probably continue to supply some of France's needs for such counts until French industry is re-established, since most of the French mills which use Indian cotton are in the invaded tract. Indian hides were bought to some extent in Germany, besides being imported direct. Moreover, a very considerable amount of chrome leather for uppers for boots—for which Indian hides are well suited—were imported from Germany. During the war this process has been developed in Italy, and much attention has been paid to the organisation and development of tanning industries. Before the war about 1,000,000 pairs of boots a year were imported into Italy. Henceforth many of these will probably be made in Italy. Manufacturers laid stress on the acceptance of arbitration at some Mediterranean port, if possible, as a very great assistance to trade. There is scope in hides for a considerable development, and it was a trade notoriously under German control. In oilseeds the position is an interesting one, as it seems to be resolving itself into a struggle against natural economic forces. Castor, which is used for industrial and medicinal purposes, will always be required; but the large future depends on the edible vegetable oils. Italy, with its olives, has been from most ancient times an oil-eating country, and it still prides itself on the quality and purity of its best olive oil. Consequently, in Italy foreign oils and oilseeds are subject to heavy duty on entry. But very largely owing to disease among the trees, production has steadily fallen from 73,000,000 gallons in 1870 to under 40,000,000 in 1913 and 1914. Exports have similarly dwindled from over 20,000,000 to 7,000,000. Meanwhile, the imports of oils and oilseeds have steadily risen in spite of the duty. The local manufacture of soap is also hampered by these duties. Due to lack of labour and attention during these years of war, it is possible that the production of olive oil may still further decline, but it is most improbable that the duties on imported oils and oilseeds will be removed. Most of the growers of olives are small agriculturists in the south of Italy—a class which many say has already suffered by the fiscal policy of the country, and one which looks on this duty as one of the few operating in their interests. Moreover, Government revenue is needed. In spite, however, of the duty and of these vested interests, all things point to more edible oils being needed in the country; and especially whilst freights are high it will probably be preferable to send oil and not oilseeds. The chief competition will be from palm oil, presumably from West Africa, and in cottonseed oil from America. Tanning materials, mica, lac, rubber and gums were also asked for. Indian hemp is required, but once more complaints against quality are to be heard. Coir matting is in use, but appears to have been entirely bought as a manufactured article from Germany. Indian wheat was very largely blamed for the presence of dust, barley grains, and weevils; and although it is well suited for the manufacture of paste and macaroni, the Italians said they only bought it when the Russian and Rumanian crop was short. Latterly, during these years of war, Canadian wheats have been coming to

Italy. Some idea of Italy's needs for wheat can be gathered from the fact that in peace times her total imports are worth about £17 millions, as compared with about £42 millions into the United Kingdom for both wheat and flour. As for jute—jute will always be needed as general trade expands.

Thus there is every probability that there will be a wider field for Indian produce in Italy, and in the past a not inconsiderable share of such trade has been done by non-Empire firms. The Italian market has also improved greatly in general reputation, and deserves to be better known. But German commercial interests were very strong in Italy, and Germany will certainly try to regain some of her position. Care is thus needed in forming connections and appointing agents. Fortunately there are now several strongly-supported organisations, especially the British Italian Corporation, of 3, Lombard Street, with its allied company in Italy definitely working to assist and promote trade relations in both directions between the British Empire and Italy. Italy has surmounted many of her earlier difficulties, and in her industries is showing ingenuity, energy and faith in the future. Trade, too, should be looked for in both directions, for many kinds of Italian goods seem well suited for India's needs, *e.g.* raised cotton goods, electric fans, caps, sulphur, glass, potatoes, coral, etc., and in this trade, and also in outward shipping, German and Austrian houses had a large share. Until trade in goods in both directions more nearly balances, the need for closer co-operation between banks was urged, and better outward services of steamers. In Italian shipping German interests were before the war very strong.

The points I wish to bring out in respect to Italy are—

i. Indian exports to Italy consist almost solely of articles needed in Italy, and are practically all used in Italy.

ii. The volume of the trade from India to Italy depends directly on the welfare of Italian industry.

iii. Before the war Italian industry was in a fair way to surmounting many of its initial difficulties connected with capital and motive power, and was giving proof of vitality and stability.

iv. Italy undoubtedly possesses men—potential workers, potential consumers.

v. The old prejudice against much of the Italian market is said to be out of date.

vi. Germans and Germany exercised before the war much financial and commercial power in Italy.

vii. That, for the time, has gone. This war is for Italy largely a war of emancipation and self-realisation.

viii. Many very strong interests in Italy are desirous of working more closely hereafter with the British Empire on a basis of mutual knowledge, respect, and confidence.

ix. Indian industries are not only in the main intact, but have been extended and financially strengthened during the war.

x. The strain and financial burdens of the war have been very great. This may tend, after the war, to reduce Italy's foreign purchases, but the fall should chiefly be in articles of luxury. India's goods are not mainly articles of luxury.

xi. Italian industry being ready, should find employment quickly, both in replenishing home stocks and in helping to meet demands in neighbouring countries which have suffered in the war. On the whole, it would thus seem probable that the Italian demand for industrial materials will increase and develop.

xii. Trade to be stable should go in both ways. If exchange remains against her Italy should be a cheap country in which to buy.

xiii. There would thus appear to be scope for the development of commercial relations between India and Italy in both ways. Owing to Italy's geographical position it is to the interest of India that such development results through the friendly co-operation of both countries, and without that German intervention which previously existed, especially in the trade from Italy to India.

A few points were general to all the countries we visited. Naturally our system of weights and measures came in for wholesale criticism. Even if we do not change our own system it would help trade to quote in quintals and kilogrammes. Then in most of the countries we visited import duties are high, and are calculated on weight and not on value. A manufacturer does not want to pay duty on dust or other foreign matter. Cleanliness, purity, uniformity and quality are of the very first importance in maintaining and developing our foreign trade. For instance, it is disconcerting to hear Indian hemp and cotton blamed for dust and dirt in England; sesamum seed, wheat and hemp in France; wheat, sesamum and cotton in Italy; beeswax in Russia. It is worse to be told that China sesamum, or Algerian wheat, etc., were originally inferior to Indian, but

are now delivered cleaner. They all agree that deliveries of Indian produce have very much improved of late, but they also agree that in very many articles there is still room for further improvements. The question is an important one for India; it is also a very difficult one.

India has long enjoyed a special position among the tropical producing countries of the world; she still has immense relative advantages in her settled population, her railway system, and her organised foreign trade. But competition from other quarters was coming even before the war—*e.g.* palm kernels from West Africa, copra from the Belgian Congo, cotton from Nigeria or Uganda, wheat from Algeria, sesamum and hemp from China—and though immediately after the war it may be difficult to find capital to build railways, etc., and to open up new areas, yet the big demand that will arise for tropical goods must stimulate production in countries which have already got a start. And the point is that in these countries it frequently happens that either development is under the general direction of a body in very close touch with manufacturing interests, so that care is taken from the start to ensure uniformity and quality in deliveries, or that early legislative action has been taken towards the same end. Competition is bound to come, and it will probably be not only competition in quantity but also in purity, cleanliness and quality. The matter is a very difficult one—no one who has been a director of agriculture can be ignorant of that; but if India is to maintain her high position among the trading countries of the world, these three essentials which affect vitally the methods both of production and marketing require and demand constant attention.

APPENDIX.

TRADE OF INDIA WITH RUSSIA, FRANCE, AND ITALY.

The figures in these tables are taken either direct from the Customs returns of the different countries, or from the *Statesman's Year Book*, or from trade returns of certain foreign towns issued, as a rule, by the chamber of commerce of a town.

I. India's Trade.

(A) *General.* In 1913 the gross value of India's foreign trade was £285,000,000 (excluding treasure and re-export), which placed her seventh among the trading countries of the world. Those with a larger volume of foreign trade were the United Kingdom, Germany, the United States, France, Holland, and Belgium.

(B) *Share of the United Kingdom in trade with India and other parts of the Empire:*—

	Percentage of imports from the United Kingdom to total imports in 1913.	Percentage of exports to the United Kingdom to total exports in 1913.
India	63	23
Canada and Newfoundland . . .	21	46
Australia and New Zealand . . .	55	53
The Union of South Africa	51	92
The rest of the Empire . . .	25	32

(C) *Distribution of India's chief markets (private merchandise only) in* 1913–14. Total value of these exports, £162½ millions (Indian returns):—

To foreign countries in Europe	£56	millions, or roughly	⅓
To the United Kingdom	38	,, ,,	¼
To the rest of the British Empire . .	24½	,, ,,	1/7
To foreign countries in Asia	24½	,, ,,	1/7
To the United States .	14½	,, ,,	1/11
To the rest of the World	5	,, ,,	1/32
	162½		

(D) *Nature of India's sales to Allies and Enemy Countries in* 1913:—Gross totals and articles, in which the value of exports exceeded half a million sterling. Where the value was less than half a million no entry has been made:—

(Figures in thousands of pounds sterling. Indian figures.)

Article	France	Italy	Russia	Germany	Austria-Hungary
Groundnuts .	2,131	—	—	—	—
Jute . . .	2,059	1,138	—	3,569	1,319
Linseed . .	1,214	—	—	568	—
Cotton . .	928	2,121	—	2,811	1,949
Wheat . .	891	—	—	—	—
Rapeseed .	601	—	—	551	—
Hides . . .	—	564	—	1,774	1,241
Tea . . .	—	—	1,110	—	—
Rice . . .	—	—	—	2,530	1,370
Copra . .	—	—	—	636	—
Total value of articles, each of which exceeded half a million	7,824	3,823	1,110	12,539	5,879

(Figures in thousands of pounds sterling. Indian figures.)

Article	France	Italy	Russia	Germany	Austria-Hungary
Gross value of all exports from India in 1913-14 (figures in millions)	11·8	5·3	1·6	17·6	6·7
Total exports to chief Allies in Europe (adding Belgium, £8 millions), £26·7 millions.				Total exports to enemy countries in Europe (adding Turkey, £17 millions), £25 millions.	

Thus the Allies and enemy countries shared about equally in the trade; and the purchases of Germany and Austria-Hungary were more similar to each other than either was to the trade to the Allies, except, perhaps, to that of Italy. They, of course, all competed for jute, and to a less extent for cotton.

II. Russian Trade.

(A) *Russian and Indian returns compared.*

In the Indian Customs returns goods are credited to the countries to which they are consigned; therefore, these returns show the direct sales to a country.

In the Russian returns goods are credited to the country of origin, where this is shown by the documents, and not necessarily to the country of purchase. They thus form some indication of the quantity of Indian goods entering Russia, and known as such, whether they were actually bought from India or not:—

Total value of goods consigned direct from India to Russia in 1913-14 (*i.e.* from the Indian returns)	£1,636,000, of which tea formed £1,110,000
Total value of goods received in Russia, which the documents showed had come from India in 1913 (*i.e.* from the Russian returns) . .	£3,656,000, of which tea formed £1,138,000

The value of the trade was thus at least £2,000,000 more than Indian returns indicated. Most of this was done through Germany.

The Case of Jute in 1912.

In 1912-13 India consigned direct to Russia 175,000 cwt. of raw jute.

In 1912 Russia imported altogether 944,000 cwt., of which she credited 77,000 cwt. to the United Kingdom, 132,000 cwt. to Germany, and 666,000 cwt. to India—or nearly 500,000 cwt. more than the Indian returns showed.

The returns of the United Kingdom show 83,000 cwt. consigned to Russia, which corresponds fairly with the Russian figure for the United Kingdom.

The German returns show 99,000 cwt. to Russia in German "special" trade, and another 425,000 cwt. in the general middleman trade as "jute and other vegetable fibres" to Russia.

The inference that most of that additional 500,000 cwt. credited in the Russian returns to India was bought in Germany seems fair.

(B) *Growth of Russian import trade, according to Russian returns:—*

(Values are in thousands of £ sterling.)

	Average of Years 1898-1902.	Average of Years 1908-12.	1913.
Total value of Russian imports	653	1108	1454
Percentage share therein of	%	%	%
Germany.	33	41·5	47·5
Percentage share therein of United Kingdom . . .	18·7	13·3	12·5
Percentage share therein of India.	1·2	2·2	2·5

As a matter of fact (*vide* above), many of the articles credited to India were actually bought in Germany.

(C) *The share taken by Germany in supplying Russia's needs in a few typical (mostly tropical) raw products in* 1913 (*Russian returns*).

The imports into Russia of the following raw products, cleaned rice, pepper, spices, coffee, tea, jute, copra, castor, hides, skins, tanning materials not ground to powder, beeswax, were worth £13½ millions in 1913, and of this £5 millions are credited to Germany in the Russian returns. Really, Germany had sold more of these articles to Russia than £5 millions, because, even in these articles, Russia credits India with £2¾ millions against India's figure of £1⅓ million. Germany, in fact, did half the total tropical produce trade to Russia.

III. France.

The importance of Indian groundnuts to the Marseilles oil industry:—

(Imports of oilseeds into Marseilles in thousands of tons.)

	1906.	1911.	1914.
Total of all kinds . . .	412	608	528
Imports of decorticated groundnuts (*i.e.* almost entirely from India)	111	201	271
Imports of groundnuts in shell (*i.e.* really from West Africa)	59	106	113
Imports of copra	110	173	98

IV. Italy.

(A) Italy has hitherto always imported more "fully manufactured articles" than she has exported; but before the war a position of equilibrium was being attained. Thus in the seven years from 1907 to 1913 the excess of imports over exports of fully manufactured articles was respectively 13, 15, 11, 8, 4, 4, 2 million pounds.

(B) The growth of Italy's foreign trade, and the rapid advance of Germany therein:—

	Imports into Italy.		
	1878-80	1906-10	1911-13
Value of trade in different periods referred to (that of 1878-80 as 100)	100	252	303
Percentage share therein and position of United Kingdom	% 21 Second	% 17 First	% 15½ Second
Percentage share therein and position of Germany	5 Sixth	17 First	16 First

	Exports from Italy.		
	1878-80	1906-10	1911-13
Value of trade in different periods referred to (that of 1878 as 100)	100	183	213
Percentage share therein and position of United Kingdom	8 Fourth	8 Fifth	10 Third
Percentage share therein and position of Germany	4 Sixth	14 Second	14 First

India has latterly been systematically seventh among importers into Italy (her sales to Italy growing steadily with Italy's increasing trade), and eleventh among the purchasers of Italian goods.

(C) Compares the nature of the Italo-British trade with that of the Italo-German. The figures are the percentages which the country's imports or exports under any class bore to the total import or export trade between that country and Italy in 1913:—

	Imports into Italy.		Exports from Italy.	
	United Kingdom.	Germany.	United Kingdom.	Germany.
Raw materials for industry	58	9	14	21
Materials for industry partly worked	18	23	15	40
Fully manufactured articles	22	66	43	11
Articles of food and drink	2	2	28	28
Total	100	100	100	100

Thus the United Kingdom sold to Italy mostly raw materials (largely coal), and bought mostly fully manufactured articles.

Germany sold to Italy mostly fully-manufactured articles, and bought mostly raw and partially-worked materials.

DISCUSSION.

The Chairman (Sir Charles C. McLeod), in opening the discussion, said it was very fortunate that Mr. Chadwick had been appointed Indian Trade Commissioner, as he possessed not only knowledge on trade matters acquired in India, but also knowledge obtained at first hand in the other countries with which his important paper dealt. He had shown that there was a trade between India and Russia, France, and Italy now in existence; secondly, that this country did not get the full benefit of that trade because most of it went through Germany; and, thirdly, that in order to possess the full benefit we must pay more attention to the quality of the goods produced in India. At the present time little could be done in the way of developing the trade between India and Russia, France, and Italy; but when the war was over it would be possible to increase that trade very largely. Trade could now be done between India and Russia through Vladivostok, and after the war, it was to be hoped, it would be carried on through the Dardanelles Straits. That any part of the trade between India and the three European countries in question should go through Germany was disheartening, and it did not speak very well for the enterprise of the British merchant that he should find the raw material in India and allow the German merchant to obtain the commission on it. For many years he (Sir C. C. McLeod) had been engaged on the problem of trying to secure from India not a better but a cleaner article. The ryot must be taught that if he produced a clean fibre, say, jute, he would get a far higher price for it than if he did not take the trouble to remove the sand and mud and decorticate properly. The same applied to linseed, wheat, and all other raw materials. He did not think there was any country in the world that could produce the variety of raw materials which India was capable of producing, but her trade could not be satisfactorily developed if those raw materials were not delivered in a cleaner state. If the great tracts of land in India were cultivated in anything approaching a scientific manner her trade might be enormous. There were, indeed, great potentialities there, and it was for this country to ensure that everything possible be done for the prosperity of India and her inhabitants.

Sir Charles Armstrong said he had listened to Mr. Chadwick's most instructive paper with very great interest. He was very glad that Mr. Chadwick had been able to undertake his three commercial missions, because it was very important that the position of our trade with foreign markets should be investigated from time to time. He agreed with the statement made in the paper that the most promising of the three countries in question was Italy. For many years Italy had carried on a very large trade with India, and she would continue to buy freely. A difficulty, however, that had been experienced in connection with Italian

trade just before the war was that some of the ports of Italy were not sufficiently developed for a large and increasing business. Steamers would arrive at Genoa and sometimes have to wait there for three or four weeks before their cargo could be discharged, and then the cargo had to be put into boats to wait till the wharves were cleared and it could be taken up the country by rail. That was a great hindrance to trade, and added to the cost of the material. The export trade from Italy to India had been increasing very steadily in the years just before the war, and if after the war German and Austrian goods could be kept out of India—as they deserve to be—Italy could to a very large extent supply the deficiency. He was inclined to think that, during the war, Japan had stepped in and filled the gap to a great extent, because since the war Japan had made considerable strides in all Eastern markets. He agreed with the author that France was not a very promising market. France was a very large buyer of raw material from India, but there was very little trade in the other direction, and he thought that she had so tied herself up with Customs regulations and high import duties, in order to encourage her own industries and those of her Colonies, that international trade had become very difficult. Of the three countries that the author had dealt with, Russia was certainly the most interesting. With regard to Russian competition with British and Indian goods in the Persian markets, in the ten years before the war Russia had made great strides. Before that time Russian goods were confined to the markets of Northern Persia; but during the last ten years before the war they penetrated into Central Persia, and into some of the markets of Southern Persia. Russia, of course, had the advantage of an easy entry into Persia, and it was much more difficult for goods to be brought into the interior of Persia from the south coast, as was the case with British goods. Now that we were in possession of Baghdad, however, our trade to Persia ought to be very much easier; but the best thing to do would be to build the railway that had been proposed from Mohammera, at the head of the Gulf, to Khoremabad. The people of Persia were wealthy, and could afford to pay high prices, and it was certainly a country that we ought not to neglect. With respect to the trade in Indian raw materials which reached Russia *viâ* Europe, the author had stated that Hamburg was a cheaper port than Hull or London, and if that meant that it was cheaper for the Russian buyer to purchase for shipment *viâ* Hamburg instead of *viâ* Hull or London, he was quite right; but as a matter of fact Hull was quite as cheap a port as Hamburg, and, so far as the transhipment trade was concerned, London was only slightly dearer. Hull was really a first-class port and ought to be encouraged; but the difficulty was that freight from India to Hamburg, Hull and London was practically the same. When Indian goods were required by Scandinavian or Russian buyers, those which had come *viâ* Hull or London had to be shipped across the North Sea, which of course added to the cost. Of recent years German bankers had afforded very great assistance to traders in Hamburg, and had given them considerable financial facilities, so that traders in Hamburg could give long credits to their Scandinavian and Russian buyers. They had offered similar facilities to brokers in London, but only on condition that the trade was done *viâ* Hamburg. Germany had also been placed in a more favourable position, owing to the fact that by penetration she had obtained partial control of some of the mills in Russia. In order to bring the trade back to this country, British ships in Indian ports should be placed in a better position than ships belonging to foreign countries. Direct shipments from India might also be encouraged. In connection with oil seeds, the re-export and transit trade of Great Britain amounted to 76,000 tons in 1895, and had dropped to 47,000 tons in 1913; whereas the German export trade from Hamburg had increased from 73,000 tons in 1895 to 250,000 tons in 1913. That showed that whilst our trade was a small one and was declining, the Hamburg trade was a larger one and was steadily increasing.

Sir J. D. Rees, M.P., K.C.I.E., said that everyone in this kingdom, especially those who had money invested in Russia, took an interest in the future of that country, and from inquiries he had made in the City, he found the general opinion was that investments in Russia need not be looked upon with despair. There was a good prospect that in the end the sane elements in Russia would reassert themselves, and that those who had capital invested there would not lose it. The author had spoken of the difficulties of the Russian language, but he thought they were very much exaggerated. They chiefly arose—as in the case of all foreign languages—from the obstinacy and lack of intelligence of those who taught the language and prescribed the course of study. The Russian language was not really a difficult one, and he hoped no commercial or other interest would be affected by its supposed difficulty. He had been very much struck by the remarks the author had made with regard to cotton and tobacco. At the present time there was a committee sitting in India in the hope of inducing the Indian people to pack their cotton and tobacco in a better condition. Owing to the carelessness and slovenliness of Indians in that respect, the Indian trade had been placed at a great disadvantage and had suffered very seriously.

Colonel C. E. Yate, M.P., C.S.I., C.M.G., said that twenty-five years ago, when he was Consul-General at Meshid, in the north-west of Persia, he met General Kuropatkin, who suggested that railways should be built between India and Russia so as to increase the trade between those countries,

but after discussion they found that, owing to the Russian Customs cordon and cost of transit, there were no goods that could then usefully be exchanged. What a change had come in late years! The author had indeed mentioned that the trade in tea had increased between Russia and England, and that that trade had been almost entirely developed by Russian merchants in Calcutta, and had also said that the Indian merchant in Calcutta had done practically nothing to develop direct trade between India and Russia in any way, but the appointment of an Indian Trade Commissioner and the establishment of an Indian Trade Bureau in London showed the progress that was being made, and he believed the prospects of trade with Russia in the future were very good. There was a trade in tea between India and Russia worth £3½ millions alone, and the author had given in the appendix to his paper a list of a dozen different articles for which there was an enormous demand in Russia, worth in 1913 £13½ millions. That trade could no doubt be developed if only the purity, cleanliness and quality of Indian goods could be secured. The Government of India ought to look seriously into that matter and try and secure the cleanliness of the articles sent out of India. Mr. Chadwick had pointed out the importance of this to India, and they looked to the Government of India to take the necessary legislative action in the matter.

MR. J. T. MEADOWS SMITH (Secretary of the British Chamber of Commerce in Paris) said the author had thrown considerable light on the probable trend of commercial relations between India and France in the future. One thing that prevented free traffic between the two countries was the fact that France applied the duties of her maximum tariff to very nearly all Indian products, those duties being, as a rule, 50 per cent. higher than the duties of the minimum, or most-favoured nation, tariff. Certain goods, such as tea, coffee, and spices, could be imported into France from India at the lower rates, but tea and spices from French colonies still had an advantage over those coming from India, as they had to pay no duties at all, as a rule. The fact that most Indian goods had to pay such high duties often prevented their sale in the French markets, and it also operated to the disadvantage of India in another way, because India was not only a great country of production but also a country of transhipment, there being a certain amount of transhipment going on in Calcutta from countries further east. The French rule was that, supposing goods originated in a country enjoying the most-favoured nation treatment, but were, before reaching France, transhipped from a port in a country which did not enjoy that treatment, those goods lost their right to benefit by the most-favoured nation treatment or by the minimum tariff upon their arrival n France. Therefore if goods from China or Japan were transhipped at any British Indian port or in Ceylon, they lost their right to the minimum tariff when they reached France. It would be essential for France, immediately after the war, to receive large quantities of raw materials, many of them being obtainable in India, such as jute, oil seeds, hides, etc., and then India would have the finest opportunity she had ever had for asking the French Government to grant to Indian goods the duties of the minimum tariff. Another thing that hindered trade between India and France was the *surtaxe d'entrepôt*, which all Indian goods coming to France had to pay if they were transhipped at a port not belonging to France. That surtax was usually 36 francs a ton, but in the case of tea it was 600 francs a ton. In the course of his official duties he came into contact with Lyons silk manufacturers, and found that they used comparatively little Indian silk, with the exception of certain classes of *tasar* made from the wild silkworm, and preferred to purchase Japanese and other silks. It might be possible, by working on the lines indicated by the author and constantly aiming at the perfection of Indian products, to make Indian silk as popular in France as the Japanese silks.

On the motion of SIR CHARLES S. BAYLEY, G.C.I.E., K.C.S.I., seconded by Admiral HON. SIR E. R. FREMANTLE, G.C.B., a vote of thanks was accorded to Mr. Chadwick for his paper.

MR. CHADWICK, in reply, said the subject was a large one and it had only been possible to enumerate the chief points which came to notice in their tour. There was not time to elaborate them. He would readily try to explain further if any one wrote. He endeavoured to keep strictly to facts and to avoid expressions of opinion. Sir Charles Armstrong, however, tempted him to mention a general impression which he did obtain. This was but an opinion, and he should be sorry if any one accepted it without careful examination for himself. Directly after the war there was likely to be a very general demand for our Indian products. But, taking a little longer view, Italy, as Sir Charles said, seemed to possess the most possibilities for India of the three countries. In France their products were already well known, and they must expect, sooner or later, more competition from the French colonies. In the far long run Russia, with its immense possibilities and large population, would possibly be the most valuable market of the three, but development would be slower, and organisation was essential for success. It should, however, pay, and therefore not be neglected. In Italy prices might not possibly be so good, but his own impression was that the Italian market was likely to develop most quickly of the three. Also, if goods were required which could not be obtained either in India or in this country, it would very often be worth while to inquire in Italy. That, he gathered, was also Sir Charles's opinion, and he thanked him for expressing it. He also unerringly placed his finger on a weak spot in Italian trade—shipping. He (Mr. Chadwick) heard many complaints in

Italy about differential freights to Genoa. He also heard many complaints about delays at the ports. And he was sure that their Italian friends would agree that quick and efficient handling of goods at ports stimulated trade, whilst the reverse was apt to discourage it. Sir Charles McLeod referred to the need of greater care in the grading and marketing of our produce. This was vastly important, but he would only mention one point in connection with it. It did not matter whether a factory was in Milan, Lancashire, Bombay or Lyons. It needed to be certain of the quality, purity, and cleanliness of the raw material it used. It was not only to the advantage of their reputation in foreign markets that their produce came to hand standardized, uniform, and clean, but to the advantage of their Indian industries, which they expected would develop and extend. The establishment of local industries also reacted on these essentials, because a local industry was often in a better position—if it would—to handle small consignments of better produce than was a large export house. It was, therefore, better able—if it would—to give that slightly enhanced price for quality which was needed to induce producers to pay special attention to these points. The merchant houses had done much in this direction, often at loss and inconvenience, and had repeatedly drawn attention to these points, but the method of their business did not facilitate the ready handling of small lots of better quality. The extension in India of efficiently managed industries ought to lead not only to a better balanced economy, but also to favour the improvement of their grades of produce, and so assist in retaining for India her pre-eminent position among the tropical trading countries of the world. Colonel Yate had commented on the changes time had brought. But they all hoped that they were merely on the threshold of greater economical advances as presaged by the development of their mills, the success of Tata's Iron and Steel Works, the inquiries of the Industrial Commission, the work of the Munitions Board, and the inception and founding of industrial banks. He was greatly indebted to the gentlemen who joined in the discussion for the criticisms and information they had given, and above all for the expressions of their belief in the future—they were more qualified to speak than he was.

Mr. G. Manzi-Fè writes that he is entirely in agreement with what Mr. Chadwick reports in respect of Italy. "I am," he continues, "particularly interested in the question as Managing Director of the British Italian Corporation, whose purpose is to assist financially in the development of trade between Italy and all parts of the British Empire. India has at the present moment our special attention, and we are endeavouring, with our Italian friends, to make such arrangements as we believe best calculated to further the development of Indo-Italian trade."

Mr. A. D. Jackson writes emphasising the necessity for some legislation on the subject of adulteration so far as India is concerned. He adds: "The short-sighted policy of the natives seems likely to handicap them severely in foreign markets in the future as it has done in the past."

PRODUCTION OF SIM-SIM IN EAST AFRICA.

The production of sim-sim or sem-sem (*Sesamum indicum*) seed is an important agricultural industry on the east coast and in the interior lake districts of Africa, writes the United States Consul at Mombasa. The total exportation of this product from the Protectorates of British East Africa and Uganda during the year ended March 31st, 1915 (the latest available detailed statistics), amounted to 27,985 cwt., valued at £21,129, of which amount about 20 per cent. was produced in Uganda, and the remainder on the coastal plain of British East Africa. In that year 28 per cent. of these exports went to India, 22 per cent. to Aden, 18 per cent. to Italy, 15 per cent. to Italian Somaliland, and most of the balance to Zanzibar and France. In former years Germany was the largest purchaser. These figures, it should be understood, do not represent the total production of sim-sim within the territory mentioned, inasmuch as a very large amount is consumed locally.

The sim-sim plant is an annual, growing from 2 to 4 ft. in height, and produces a seed that yields a high percentage of fixed oil. This oil is often used as a substitute for olive oil, and even for oil of almonds. Locally, as well as in India and other countries having a large Indian or Arab population, the oil is used extensively for cooking purposes. The plant thrives in a light, sandy loam soil in very tropical districts. About 16 lb. of seed are used per acre, sown broadcast or in drills 18 in. apart during the months of April and May. It requires about four months for the crop to mature. At the time of harvest the plants are pulled up, gathered into bundles, and left in the field until thoroughly dried. They are then thrashed, and the cleaning is done by hand-winnowing with sieves. An average yield is 180 lb. of clean seed per acre under present native methods, but European settlers who have practised more careful cultivation have obtained double and even treble that quantity per acre.

The Mombasa market price for white sim-sim from Uganda at the beginning of 1917 was 27 rupees (£1 16*s*.) per "gisla" (285 lb.). The yellow seed produced in the lake district of British East Africa sells for about 1 rupee less per "gisla." For export, the seed is packed in bags containing 180 lb.

ENGINEERING NOTES.

Aero-steam Railway Traction.—There is nothing new in steam, or in compressed air, traction. There is, however, a new feature in the combination of these two fluids with compound expansion. We find, says the *Engineer*, in the Proceedings of the French Institution of Civil Engineers, a brief account of aero-steam traction, and a report thereon has been made and a description given by M. Guadon as follows: If firing is stopped on a railway locomotive—or, in certain cases, only continued with drygood coke—and the cylinders are thenceforward supplied with compressed air taken from reservoirs carried on the tender, or from a special compressed-air tender, this "aero-steam" will continue to run the train for a relatively long time without the emission of either smoke or steam, the exhaust vapour from the cylinder being actually condensed into water by the refrigeration which results from the expansion of the compressed air, if this expansion is carried sufficiently far by means of a multiple expansion of the mixed vapour. This is applicable to the following cases, as regards steam locomotion: (1) Tunnels in which the emission of steam or smoke cannot be tolerated; (2) heavy grades on which it is desired to augment speed; (3) metropolitan or suburban lines with frequent train stops, upon which an acceleration of starting speeds is required. Plans are advanced for aero-steam traction in the tunnel about fourteen miles long through the Ural Mountains in Russia.

A New Niagara Falls developing 2,000,000 *h.p.*—Almost everyone remembers the lower Niagara River as running through a narrow gorge which is about 500 ft. wide at the water-line and about 1,000 ft. between the tops of the banks, standing from 300 to 350 ft. above the water, and all realise the naturally great difficulty of a dam in such a location. A glance at Foster's Flats, about 4½ miles below the falls, will show at once how this simplifies the work: more than half of the dam can be built on dry land. This first half will then afford an easy means of diverting the water from the present channel before building the rest of the dam, where the water now flows. There is a 102 ft. drop in the Niagara River from the base of the old falls to Lewiston, with a minimum flow of 220,000 cubic ft. per second. Now, this total head and volume should be developed as a unit in one large dam. The most economical method in developing the river, of course, is to use as much water at the falls as the Governments will allow, afterwards returning the water to the river directly below the falls so that it can be used over again at the proposed new falls made by the dam at Foster's Flats. The masonry structure will be about 1,200 ft. long and 150 ft. high, and it will raise the downstream level of the river about 100 ft. The power-houses would extend downstream from the dam on both the Canadian and American sides, considerable distances being required to accommodate the many turbines necessary. These particulars are from the *Engineering News-Record*.

Rain-making Device.—In the course of his tour of the Trans-Continental Railway, the Minister of Works and Railways, Mr. Watt, inspected the rain-making device set up by Mr. J. G. Balsillie, late Commonwealth Wireless Expert, at Bookaloo, in the vicinity of the Trans-Continental line; and upon the evidence placed before him he has decided that the experiments should be continued. Comparisons made and data collected over some fifteen or sixteen years indicated that Mr. Balsillie's scheme had induced an increased rainfall of between 50 and 70 per cent. in what was known as the Bookaloo area, about fifty miles west of Port Augusta. The Bookaloo apparatus had been shifted to Wynbring for further trials, which would be continued for a considerable period. The Federal Government proposed to obtain two more plants from Mr. Balsillie, and, after consultation with the Government Meteorologist, use one in New South Wales, and possibly one in Victoria, in grazing and wheat-growing areas respectively. The cost of each plant, with a full year's upkeep, was about £800.

Inland Water Transport on the Continent.—In Germany the four chief rivers, Rhine, Elbe, Oder, and Weser, carry four-fifths of the total waterway traffic of Germany. The Rhine carries 43 per cent. In France, the Seine transports 20 per cent. of the total traffic, while the artificial waterways of the north-east of France carry 36 per cent. In Belgium the traffic on the Scheldt forms one-fourth of the whole traffic, and more than half of the total traffic is carried on one-third of the mileage. The intensity of traffic on Continental waterways is much heavier than in England. The average length of travel in Germany is 139 miles, in France 92 miles, in Belgium 13 miles, while in England it is about 17 miles.

The Expansion of Quicklime.—This, when wet, develops an enormous force that acts slowly and almost irresistibly, and has long invited use for mechanical purposes. Successful efforts to utilise this force have been noted in a recent issue of *Rock Products*, which describes its efficient use in breaking up heavy brick masonry. Several 12 ft. by 20 ft. piers, 12 ft. high, were situated between similar foundation piers for engines in operation, and it was necessary to remove them without injuring the machinery. Blasting was therefore inadmissible, and hand-cutting and breaking too slow and expensive. The work was accomplished by drilling 3 in. vertical holes 3 ft. deep and 3 ft. apart in both directions over the entire area of the piers, and filling them within 6 in. of the top with fresh slaked lime, in pieces ½ in. to 1½ in. wide. As soon as the lime was thoroughly wet the tops of the holes were filled

with brick drilling well tamped, and in about ten minutes cracks started in every direction, and the entire top of the foundation pier was broken into 3 ft. cubes.

The Mineral Wealth of Alsace and Lorraine.—M. J. P. Bedson, in his inaugural address to the Manchester Association of Engineers, referred, amongst other matters, to the mineral wealth of Alsace-Lorraine, and pointed out that the invention of Thomas and Gilchrist turned that country into a vast gold mine, by rendering its iron ore useful and valuable. The German ambition is to secure also the great iron basin of Briey, the richest and most extensive of all Europe, estimated to contain from 3 to 4 thousand million tons of ore. Thirty miles away nature has deposited 10,090 million tons of coal in the basin of the Sarre; east of Nancy, partly in France and partly in Lorraine, is one of the largest salt beds in the world; farther east, at Pechslbronn, is an oil district whence 30,000 tons of mineral oil are extracted yearly; and finally, more to the south, near Mulhausen, is a wonderful deposit of potash, rivalling that of Stassfurt.

Assam Oil.—Sir Boverton Redwood, speaking at the general meeting of the Assam Oil Company, said that he attached great importance to the work that had been done during the past year in opening up new territory. For some years they had been hopeful of linking up the two areas which had been productive, and during the past twelve months that work had been proved to a point which entitled them to form the most hopeful anticipations. So confident was he of the deductions which might be drawn from the results obtained that, in his opinion, it had now become essential for the directors to take into consideration an extension of the refining capacity of the company, and a report on that matter had been submitted to the board for their consideration. He added that the results as a whole could not be considered as otherwise than gratifying, and of hopeful augury for the future.

GENERAL NOTES.

Production of Sulphuric Acid in Japan.—H.M. Commercial Attaché at Yokohama (Mr. E. F. Crowe, C.M.G.) reports that the increased export of sulphuric acid from Japan to Russia and China since the beginning of this year has led to steadily advancing prices of this commodity in Japan, and a considerably increased output. Several manufacturers of fertilisers have reduced their output and are devoting their energies to the production of sulphuric acid, while a number of companies have been established for the production of this chemical alone. It is estimated that the rate of production of sulphuric acid in Japan at present is some 582,500 tons per annum. Of this quantity about 421,000 tons are consumed by manufacturers in the production of sulphate of ammonia, hydrochloric acid, etc., leaving some 160,000 tons available for general requirements in the country, which are about 100,000 tons a year. Thus there are about 60,000 tons available for export. It is taken for granted that on the conclusion of the war the export trade will fall off, and it is also probable that there will be a considerable decline in domestic requirements. It is estimated that the output of sulphuric acid in Japan, if continued at the present rate of production, will be some 100,000 tons in excess of the demand on the resumption of normal conditions.

Oil Industry of Trinidad in 1916.—According to the report for 1916 by the Acting Colonial Secretary for Trinidad and Tobago (*Colonial Office Reports, Annual Series*, No. 930), there were ten companies engaged in the production of petroleum in Trinidad at the end of 1916. The total output of oil in that year was 32,475,695 imperial gallons, as compared with 31,666,396 imperial gallons in 1915. Drilling to the extent of 58,390 feet was carried out during the year. Oil was struck in thirty-four of the forty-seven wells drilled. The total number of wells drilled in the Colony up to December 31st last was three hundred and twenty-five. Several refineries have been engaged in the production of petrol, for which there is a large demand locally, as well as in some of the neighbouring islands. Kerosene has also been produced for local consumption. The value of crude petroleum, fuel oil and petrol exported from Trinidad in 1916 was over £200,000, as compared with £79,000 in 1915, thus bringing oil into the third place of importance in the list of exports from the Colony.

Oil from the Bicuhyba Nut.—The Brazilian "bicuhyba" nut, which is found principally in the States of Minas Geraes and Espirito Santo, is understood to have been tested in the United States as an oil-producing nut. The meat is said to contain slightly more than 60 per cent. of fats, and the shells a little more than 4 per cent. The meat of the nut constitutes about three-fifths of its entire weight. Assuming that five-sixths of the oil contained in the meat is extractable, this would mean a yield of about 3 lb. of the saleable product from every 10 lb. of nuts. According to a report by the U.S. Consul-General at Rio de Janeiro, interested persons there who are endeavouring to create a trade in this class of raw products state that the "bicuhyba" nuts are not yet obtainable in sufficient quantities to be exported, and that each tree yields only about 35 lb. of nuts each season. It would not be possible to obtain these nuts at less than £20 per ton f.o.b. Rio de Janeiro, bringing the cost of the extracted oil to about 1½*d.* per lb., without reckoning the high freight rates prevailing.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, JANUARY 4, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 9th, 3 p.m. (Juvenile Lecture.) P. CHALMERS MITCHELL, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, "Animal Camouflage." (Lecture II.)

The lecture will be fully illustrated with lantern-slides.

Further particulars of the Society's meetings will be found at the end of this number.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and can be obtained by Fellows on application to the Secretary.

JUVENILE LECTURES.

On Wednesday afternoon, January 2nd, Dr. P. Chalmers Mitchell, F.R.S., Secretary of the Zoological Society of London, delivered the first lecture of his course on "Animal Camouflage." Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, presided.

The lecturer began by observing that in the animal world more brilliant colours and patterns were hidden than were seen. Animals dredged up from the depths of the sea were, in many cases, brilliantly coloured and adorned with intricate patterns. Moreover, colours and patterns were even more conspicuous in the interiors of animals than in their exteriors—as a glimpse at a butcher's shop in pre-war times would show; and in support of the adage that beauty is skin-deep, he suggested that if the chimpanzee and the orang, whose portraits were shown on the screen, were flayed, what remained would be as beautiful as a human being similarly treated.

It was, of course, well known that some animals seem to make themselves as conspicuous as possible, *e.g.* the bird of paradise, or the cock pheasant. A favourite explanation of this is the "wedding-dress" theory, viz., that the bird puts on his gayest clothes when he goes a-courting; but Dr. Chalmers Mitchell inclined to the opinion that, as the hen sits on the eggs and looks after the young, it is important that she should remain as inconspicuous as possible, while the cock endeavours to distract attention from her to himself both by his gay garments and his singing. Other animals, again, like rattlesnakes, try to make themselves conspicuous for different reasons. A snake is a delicate creature, and its ribs, and even its back, are easily broken; and when it is not hunting it lies out in the open, where it will be distinctly seen, and advertises its dangerous presence in the hope that it may not be inadvertently molested.

In most cases animals try to conceal themselves, and one important way of doing so is by endeavouring to match their surroundings. The leaf insect, which is considered good to eat by numerous enemies, is a fine example of this. Another instance shown on the screen was the privet hawk moth. The moth, which flies at night, is dusky, but the caterpillar is bright green, and is hard to see on the leaves of its favourite food.

After describing animals which live in snowy regions, and which have either white coats all the year round, like the polar bear, or summer and winter suits, like arctic foxes, hares, and ermine, the lecturer passed on to spotted and striped animals. Few patterns could be more conspicuous than the spotted coat of the jaguar when seen in a museum or a menagerie; but a remarkable photograph brought out the fact that when in its natural surroundings of forest, the beast becomes almost invisible.

Similarly, even giraffes blend in with their natural surroundings to such an extent that at a little distance it is extremely difficult to detect them.

The lecturer concluded with a remarkable series of photographs, in which it was shown that birds bearing colours and patterns that, out of their natural surroundings, appeared strikingly conspicuous, when in their proper environment almost disappear.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROGRESS IN THE METALLURGY OF COPPER.

By H. C. H. Carpenter, M.A., Ph.D., M.Inst.M.M., A.R.S.M.,

Professor of Metallurgy, Imperial College of Science and Technology.

Lecture I.—Delivered December 3rd, 1917.

In the last year of the eighteenth century Great Britain produced about 75 per cent. of the world's output of copper. The Cornish miners supplied most of the ore, and the Swansea smelters extracted the metal. In the United States of America only a few tons were made. In 1913, on the other hand, the positions were reversed. Great Britain smelted and refined barely 6 per cent. of the world's production of this metal, and all but an insignificant fraction of this was derived from imported ores, matte, blister copper, and precipitate or cement copper. In the same year the United States of America furnished more than 55 per cent. of the world's total, and by far the greater part of this was obtained from home supplies of ore.

The purpose of this course of lectures is to give a concise history of this remarkable reversal and, as far as may be, to account for it; to describe briefly the origin and consummation of the Welsh process of copper-smelting and refining which made Swansea so famous for many years as the centre of the world's production; and to present an outline of some of the best modern practice in the U.S.A., now the chief seat of the industry.

I need hardly remind you that, whether in peace or war, copper is, and has long been, second in importance only to iron, not only in the various types of the commercial metal, but also in its numerous alloys. The enormously greater extent to which it is now used as compared with a hundred years ago is, however, not so well known. In 1800 the world's production did not exceed 10,000 tons, and that was probably the high-water mark up to that time; in 1900 it had risen to about 500,000 tons; and in 1912 to about one million tons. Thus, in little over a hundred years production had increased a hundredfold.

It is most probable that copper was the first metal commonly employed by mankind. It has been found in the native condition in various parts of the world, and the natural product required no metallurgical treatment prior to its use. The fact that it was very malleable and could be toughened by very simple mechanical treatment undoubtedly contributed materially to its usefulness in primitive times. The mining and smelting of its ores have been carried on from time immemorial. According to Percy, the Ancients obtained the metal from various localities, among which was the island of Cyprus, where, according to Pliny, it was first discovered. The copper from this island was known in the Roman market as *aes Cyprium*, or Cyprian copper. The adjective "Cyprium" at first used only to express locality, became corrupted into the substantive *cuprum*, which replaced the original name *aes*; and from *cuprum* the English word "copper" is derived.

The Hindoos have smelted copper ores from the very earliest times, and to this day conduct the operation in small blast-furnaces about three feet high. The deposits of Britain are said to have been known to the Phœnicians as far back as 1000 B.C. So far as I am aware, a complete history of copper-smelting in this country has not yet been written, but, in the brief historical survey which I shall attempt, I wish to express my indebtedness to two important and most interesting sources of information. The one is Percy's "Historical Notices on Copper Smelting in Great Britain"; the other Colonel Grant Francis's book, entitled "The Smelting of Copper in the Swansea District of South Wales from the Time of Elizabeth to the Present Day," published in 1867. This book is largely compiled from evidence obtained in the Public Record Office.

A word, however, is necessary by way of introduction with regard to the ore-minerals of copper, more of which exist than of any other metal. Dr. Cullis* gives the following list of fourteen, and this includes only those of major importance:—

* "Mineral Resources of the British Empire with regard to the production of Non-ferrous Industrial Metals," Society of Engineers, 1916.

TABLE I.

ORE-MINERALS OF COPPER.

		Name.	Composition.	Copper per cent.
Native Ores		Native Copper	Cu	100
Oxide Ores		Cuprite	Cu_2O	88·8
		Azurite	$2\,CuCO_3.Cu(OH)_2$	55·2
		Malachite	$CuCO_3.Cu(OH)_2$	57·4
		Chrysocolla	$CuSiO_3.2H_2O$	36·1
		Atacamite	$CuCl_2.3\,Cu(OH)_2$	59·4
		Brochantite	$CuSO_4.3\,Cu(OH)_2$	56·0
Sulphide Ores	Secondary	Enargite*	$3\,Cu_2S.As_2S_5$	48·3
		Tetrahedrite*	$4\,Cu_2S.Sb_2S_3$	52·1
		Covellite	CuS	66·4
		Chalcocite*	Cu_2S	79·8
		Bornite*	Cu_3FeS_3	55·5
	Primary	Chalcopyrite†	$CuFeS_2$	34·5
		Cupriferous Pyrite and Pyrrhotite	Variable.	Variable.

* Perhaps sometimes primary. † Often secondary also.

Of these, cupriferous pyrite and chalcopyrite are the most widely distributed. They are, in fact, the original minerals from which all the others have been derived. The oxide ores are situated in the upper parts of sulphide deposits which have been oxidised under atmospheric influences, and the deposits of native metal are the result of reduction processes operating on solutions of the oxidised ores. There can be little doubt but that the first ores of copper to be smelted were the oxides and the hydrated carbonates. The sulphide ores containing copper, iron, and sulphur in addition to the gangue in which the ore-mineral occurs presented much more difficulty in their treatment and were taken up later. Professor Gowland, however, has described the production of metallic copper from sulphide ores in Japan by a process of superoxidation, and has shown that it dates back many centuries.

Limits of time compel me to restrict my survey of the industry to a period which dates from the close of the sixteenth century. In the time of Queen Elizabeth there was a rich copper mine at Keswick, in Cumberland, where it is reported not less than 4,000 men were employed. This figure is regarded by Percy as a great exaggeration. There can be little doubt but that the ore mined was a sulphide. Webster, the author of the "Metallographia," describes it as an ore "that must be often melted in the fire ere it be brought into the form of good copper." Perhaps I can best illustrate the state of the copper-smelting industry at the works connected with this mine by quoting from a letter from one George Nedham, probably an English smelter, to Sir Francis Walsingham, describing his visit in company with a certain Jochim Ganse, who was a German smelter. The letter runs as follows:—

"A description of the Doeinges of Jochim Ganse and George Nedham at the Copper Mynes by Keswicke, in Cumberland, A.D. 1581.

"RIGHT HONOURABLE,—As soone as Mr. Jochim and I came to Keswicke, the firste thing we did take in hande was to searche out both the nature and the number of the hurtfull humors that were naturally bred in oure Copper ures gotten in that countrie wherein after sundrie trialls we attained to some perfection and found that in our copper ures, were tenn severall substance's whereof iiij ar visible, w'ch ar iron, copper, a kinde of black stone (wherein the copper groweth) and a kinde of white stone named sparr: the other vj humors, w'ch ar in the said ures, and invisible ar sulpher, arsenique, antimony, vitriall, calcater, and allom; so as in ten substances which ar in our Copper ures,

he copper is one, and the other substances by their naturall operation ar all hurtful and venomous humors to the copper; for some of them by wasteinge the copper in smeltinge, and by their dryness make it bretle and black; the other by their toughe and moiste nature, be a great let to the speedie smeltinge and bringinge the ure into rough copper. The number, nature, and propertie of w'ch ix hurtful humors being wholly unknowne to Mr. Daniell and his Sonne, or to any other of the Duch workemen w'ch have bin sente from Germany to the mynes, that have borne our copper ures, had bin the onely cause of the unreasonable charge and long tyme spent before they could make of those ures perfect rough copper: which copper after the order used in tymes past by Mr. Daniell and his son thei never could, nether yet can, make under xxij tymes passing thro' the fire and xxij weekes doeing thereof and sometyme more. But now the nature of these ix hurtful humors abovesaid being discovered and opened by Jochim's way of doeing we can, by his order of workeinge, so correct theim, that parte of theim beinge by nature hurtfull to the copper in wasteinge of it, ar by arte maide freindes, and be not only an encrease to the copper, but further it in smeltinge: and the reste of the other evill humors shalbe so corrected, and their humors so taken from them, that by once roastinge and once smeltinge the ure (w'ch shall be done in the space of three days) the same copper ure shall yeeld us black copper and copper-stone, w'ch nether Mr. Daniell nor his Sonne coulde or yet can do under xvj tymes passinge through the fire and xvj weeks in doeinge thereof: and further, in once rosteinge and once smeltinge the same black copper and copper-stone again, w'ch shall be done in ij days, after Mr. Jochim's order of workeinge, I will bring the black copper and copper stone into perfect rough copper, which Mr. Stembarger cannot make under xxij tymes passing thro' the fire and xxij weekes in doeinge thereof and sometymes more!"

The letter then goes on to describe the part played by the nine impurities in the smelting of copper, and reveals a remarkably shrewd knowledge of their functions. Especially is this the case for iron, as the following quotation shows:—

"The vij[th] humor is Iron, being one of the vij metals but no mynerall w'ch being engendered and bred up in the earth with the copper ure, will not lightlie be gotten from it, and especiallie when the copper ure is smolten greene as it cometh from the myne, w'thout rostinge, then the iron doth joyne and incorporat himself w'th the copper . . . . w'ch is onely the greatest cause of so many chargable fires and longe tyme w'ch Mr. Daniell and his Sonne do spende before thei can make rough copper. And accordinge to Mr. Jochim's order of workeinge the nature and substance of the iron yt is our copper ure being beaten into powder, and rosted as aforesaide, the drosse and corruption that is in the iron is so dryed up that when it cometh to smeltinge it is not able to runne or gether itselfe together like a slagge as it doeth being smolten greene before the ure be rosted: and the best substance w'ch is the right iron ure, beinge by rostinge brought into the perfection of iron, is, by the water and strength of vitriall, converted into copper, as I have proved sundrie tymes: so as this cheefe of the hurtfull humors beinge thus corrected it is made of an enemye a freinde and helper of the copper."

George Nedham, the writer of the foregoing letter, was one of the original partners of the Mines Royal Society, formed in 1580, to which I shall have occasion to allude shortly. The Sir Francis Walsingham to whom he wrote was the secretary of the Society, which had just completed the erection of a copper-smelting works at Neath. I judge from the above letter that the best smelting practice at that period was to be found at the Keswick works, where Daniell (whose surname was probably Hochstetter, and his son-in-law, Stembarger, both of them Germans, were in charge, and that they employed, at any rate, some German workmen. It appears that it took them sixteen weeks to produce "black copper" and "copper stone" (our regulus or matte) from the ore, and another six weeks to convert these into perfect rough copper, and that twenty-two furnace treatments were necessary. The Jochim Ganse was evidently another German smelter who undertook to smelt the ore much more expeditiously, and he and Nedham, apparently acting on behalf of the Mines Royal Society, made the journey to Keswick to carry out the test. That the latter was successful is evident, for, according to the letter, black copper and matte were produced in three days, and another two days sufficed for their conversion into "perfect rough copper," which was the finished product obtained from the smelter. It is evident that, previous to the appearance of Mr. Jochim Ganse at Keswick, it took more than five months to convert the ore into copper, and it is clearly recognised that the chief cause of this very prolonged period was the

presence of iron in the chalcopyrite. On the other hand, after two roastings and two smeltings, Jochim was able to produce the same result in five days' time.

Following on this, Nedham wrote to Walsingham in March, 1582, conveying an offer made by Jochim for "the makeing of copper, vitriall, and coppris, and smeltinge of copper and Lead ures," in which he compared Jochim's charges with those of Stembarger, much to the advantage of the former, and recommended its acceptance. Moreover, it appears from the following extract from this letter that Jochim was to be engaged at the new works at Neath: "And further the said Jochim doubteth not but that after he had rosted and smolten iij or iiij saies of o'r copper ure, in the great works, after such manner as he hath devised since his comeinge from Keswick, to attaine to such farther knowledg of the nature of all o'r copper ures in Cumberland and Westmoreland that he shalbe able to kill all the corrupt humors that be in them, and thereby to bring out more copper than heretofore hath byn."

I have given the above correspondence at some length, not only on account of the interesting picture it gives of the condition of the copper-smelting industry in the year 1581, but because it describes the initiation of what must have been a veritable revolution in ore treatment as a result of Jochim's successful smelting of the Cumberland ores, and because, so far as is known, the smelter alluded to at Neath was the first to be operated in Wales, and may therefore be regarded as the birthplace of the Welsh industry. You will have noticed how closely identified with copper-smelting at that time were German workmen. It is probable that the early ore furnaces of the primitive blast-furnace type in Britain were worked by Germans experienced in that class of work. The matter, however, did not pass without protest. Let me quote from a letter written by Mr. William Carnsewe to Thomas Smyth (January 15th, 1583), who was the "Chief Customer of London to Queen Elizabeth" and the founder of the copper trade in the Swansea district:—

"Mr. Weston's p'vydence in bryngynge hys Dutche myners hether to aplye such busynys in this countrye ys more to be comendyd then his ignorance of o'r countrymen's actyvytyes in such matters, who owte of all p'adventure be as skylfull in mynyge, as harde and dylygent laborers and as good chepe workmen in that kind of travell as are to be founde in Europe; whereof to make you good p'ffe lett the same Mr. Weston's Germans have some myn assignyd only to them, and lett yo'r Ulryke take suche as he is now acquantyd w'th of our countrymen, and the sam that wreoght in that worke at Treworthye laste when it was by Burchardys frowardniss gyvyn ov'r w'che was abowte 23 yerys paste (1560) and let it be consyderyd w'che of them for on hole somers space shall put yow to moste chargys, and gayne yow moste, and soo of them that doo lesse you shall make yo'r estymacyon by p'ffe."

I have not been able to discover whether this test was carried out; it was certainly a fair one.

In the time of Elizabeth, James, etc., the metalliferous ores of this country were reserved to the Crown, and it was necessary to have a grant for the searching for and working of them, and further it was necessary to have a patent or Crown grant for the constitution of a company or aggregation of persons. The Mines Royal Society was constituted in 1580, and obtained its Charter in 1604. There were twenty-four shares, half of which were held by the English and half by foreigners. That the Crown shared in the profits of the undertaking is evident from a note or order on September 6th, 1595, by Lord Burghley that "the Royal Company of Miners should certify what copper they have and how much they owe to the Queen and Customer Smyth's Exors. to answer for copper delivered." The Mines Royal Company lasted for more than two hundred years and conducted operations at Neath. How small the scale of working was even at the end of that time is shown by the following extract from the books of Mr. John Place, their manager:—

"Oct. 10, 1796.—Ores smelted this week 136 tons. Copper made 17 tons; Furnaces working 38; Coals burnt 315 tons."

From this you will see that the weekly output of metal per furnace was less than half a ton, and that the coal consumption was 18·5 tons per ton of copper. The entry of May 16th in the same year is also interesting. "Coal so bad the men left the works for two days." To the Mines Royal Society Wales was indebted for the first copper works established in that country. Nearly one hundred years later two other companies started operations, almost simultaneously, in Glamorganshire. The one was Sir Humphrey Mackworth's "Company of Mine Adventurers," who established works at Melincrethyn about one mile from the town of Neath, where great heaps of copper slag can still be seen. It was also known as the English Copper Company.

Its charter dated from 1691, and it began work in 1695. It appears from entries in the records of this company that it was customary to employ criminals in their mines. Thus: "Sept. 6th, 1700.—An account received that 17 condemned criminals had been pardoned by the King, provided they would within two months, apprentice themselves to Sir H. Mackworth and partners for five years to work at the mines."

"Oct. 16th.—Reported that two of the criminals sent to Neath had run away."

The other company was called "the Governor and Company of Copper Miners in England," and they erected works at Taibach. These were the pioneers of the famous copper-smelting and refining industry of South Wales.

According to Colonel Francis a document in the Muniment room of the Swansea Corporation proves that the first copper works in the Swansea area were erected in 1717. It reads as follows: "In the year 1717 works were first erected upon the river at Swansea for smelting copper and lead ores which works are situated above the town and about two miles beyond the extent of this Corporation. In the year 1720 another work was erected upon Swansea river for smelting of copper ores which is situated within the limites of the Corporation" at Burlaisbrook Junction with Tawe. The dates of the establishment of these and various other works, as given by Colonel Francis, may be tabulated as follows:—

TABLE II.

Place.	Company.	Date.
Neath	The Mines Royal Society.	1584
Melincrethyn	Mine Adventurers	1695
Taibach	Copper Miners	1727
Swansea.	Lane and Pollard	1717–20
Penclawdd	John Vivian	1800
Llanelly	Daniell, Nevill and others	1805
Loughor	Morris and Rees	1809
Hafod	Richard Hussey and John Vivian	1810
Cwmavan	Vigoes and Son	1837
Pembrey	Mason and Elkington	1846

It thus appears that copper-smelting had been extensively carried on at or near Neath for a considerable period before it was established at Swansea, and that it had attained a considerable degree of development there at least 120 years prior to its introduction into the latter town.

I must now pass on to consider briefly why the copper-smelting and refining industry came to be established in South Wales and was able to maintain its position as the greatest producer in the world of the metal from the beginning of the eighteenth to the middle of the nineteenth century. The ores were mined in Cornwall and Anglesey. Why were they brought to South Wales for conversion into the metal? The Cornish pyritic ore was a by-product in the mining of tin, and was originally thrown aside by the miners, under the name of "poder." In the eighteenth century several unsuccessful attempts were made to smelt the ore in Cornwall, of which a record has been preserved by Tonkin. Carew, in his "Survey of Cornwall," first published in 1602, wrote: "Touching metals: Copper is found in sundry places, but with what gain to the searchers I have not been curious to inquire nor they hasty to reveal; for, at one mine of which I took a view the ore was shipped to be refined in Wales either to save cost in fuel, or to conceal the profit." It is clear from the language of the writers of the eighteenth century that the Cornish Mine Adventurers regarded themselves as the victims of a conspiracy on the part of the Welsh copper-smelters, but, as Percy shrewdly remarks: "It is difficult to understand why copper-smelting should have ceased in Cornwall if it had really been profitable. In one instance at least failure was not due either to deficiency of capital or incapacity in the management. As the adventurers felt themselves so much aggrieved by the smelters they might have entered into a combination to keep up the price of copper ore. Of all facts none are more stubborn than those of political economy; and the truth of the matter appears to be that copper-smelting can be conducted with greater profit in Wales than in Cornwall, and therefore it has become extinct in the latter county. . . . It would be difficult to select in this country a more eligible site for copper-smelting works than Swansea, and this for two reasons. The first is that it is a good seaport which is only at a small distance from Cornwall and Devonshire, the two counties in which the greatest amount of copper ore is raised, and it is also easily accessible to vessels conveying ore, or products containing copper, from South America, Australia, and other parts of the world. The second is that

extensive collieries exist in the immediate vicinity from which an abundant supply of coal can be obtained at a low price. Many of the smelters are themselves engaged in the working of collieries, and are thereby enabled to dispose of their coal to the greatest advantage, the large being sold at a good profit, either for home consumption or exportation, and the small, which is often very dirty from an admixture with shale, being reserved for the copper furnaces. It is advantageous both for the mine-adventurers and the smelters that the process of smelting should be carried on in a locality where copper ores of various kinds may be procured, for it is well known that frequently copper can be extracted at a less cost by smelting several ores in admixture than by smelting any one ore by itself."

Few, I imagine, will disagree with the former reason advanced by Percy, but it is not clear to me that the latter had much, if anything, to do with the choice of South Wales for smelting operations in 1584. We must remember that at that time all smelting was carried out in small shaft or blast furnaces, and that charcoal was the fuel used. Coal was not, so far as I know, employed as a fuel in such furnaces. It appears, however, that between 1584 and 1700 the Neath metallurgists had discovered that the free-burning South Wales coal could be used for copper-smelting, and had evolved the reverberatory furnace for that purpose. Indeed, this was a case where the character of the fuel rendered necessary a completely new technique of roasting and smelting. Information with regard to this most interesting change is, unfortunately, I believe, entirely lacking. It is, however, important to note that in his letter of March 1582, Nedham advances as one of the reasons for accepting Jochim's tender, the undertaking of the latter to use nothing but peat in the roasting operations, whereas Stembarger and his father-in-law required to use wood. In the light of this it appears to me not improbable that Jochim and his co-workers would carry out tests on the coal so plentifully abundant in South Wales with a view to adopting it both for roasting and smelting operations. Be that as it may —and whoever made this discovery—once the special adaptability of South Welsh coal for reverberatory firing had been established, and the technique of the new process worked out, smelting practice in this country and on the Continent diverged. In Central Europe, where enormous forests furnished wood suitable for making charcoal, a fuel which necessitates close proximity to the furnace charge, blast-furnace smelting continued to develop and exists to this day, the main difference being that coke has largely replaced charcoal as the fuel. In South Wales, on the other hand, smelting processes developed along the lines of reverberatory practice, and resulted in the establishment of the famous Welsh process. The essential condition for successful reverberatory firing is that the heat must be applied at the right place, and that place is the charge on the hearth—not on the grate or in the flue. What is required is an abundance of incandescent solid particles burning with a more or less opaque yellow or white flame due to incandescence. A very large part of the heat utilised by the charge is received by direct radiation from these particles, and it is this type of combustion to which the free-burning coals of the Swansea coalfield lent themselves in the reverberatory type of furnace.

After reverberatory-furnace smelting had been established there was never any question but that Swansea was a most suitable location for the industry. Fuel was at that time the largest item of expenditure, and remained so throughout the entire period of prosperity of the industry in South Wales. I have already quoted figures showing that at the end of the eighteenth century the consumption of coal per ton of copper produced was 18·5 tons for the mixtures then smelted. This figure had hardly been improved upon at all in 1861, when Percy published his book, for he then estimated that for every ton of copper made from a mixture of ores containing about the same proportion of this metal, 18 tons of coal were still needed. Accordingly a situation where cheap and suitable coal could be obtained was always of the highest importance to this industry. Whether the occurrence of high-class refractory clays suitable for fire-bricks and furnace linings in the immediate neighbourhood of Neath had anything to do with the choice of this place as the original smelting centre is a matter of conjecture. I am inclined to think that it had. At any rate, the existence of the famous Dinas rock in the Vale of Neath was a fortunate circumstance for the copper metallurgists. It found application in the manufacture of furnace bricks and hearth linings, as also did the blown sands on various parts of the coast, some of the best qualities of which are found at Briton Ferry, near Neath.

Preliminary Treatment of the Ores.

The Cornish ores, previous to being smelted in South Wales, were dressed and sampled at the

mine. They consisted chiefly of copper pyrites, intermixed with small quantities of other cupriferous minerals, iron pyrites, and the constituents of the vein in which the ore was found. For convenience of dressing they were divided into three sizes by being dropped on to two rows of inclined bars which separated them into what were termed rocks, roughs and smalls. Each of these then received an appropriate treatment, in which hand-hammering, followed by hand-picking, rolling in a crusher, and jigging, played their part, as a result of which the copper ore was concentrated and yielded two products, the one known as "prills" and "smalls," the other as the "dredge." The former was the richer of the two in copper. These were subdivided into "doles" by means of a measure called a "barrow," which, when filled with ore, weighed about 1·5 cwt. The doles were sampled and assayed by the smelting companies' assayers, and on the basis of their results the various companies fixed the prices they offered at the approaching sale or "ticketing."

It should be remembered that the mining of copper in Cornwall was responsible for the introduction and successful working out of the use of steam power in engineering. "On account of the increasing depth and extension of the Cornish mines, the problem of disposing of the underground water became urgent, and led to the introduction of steam engines for driving the pumps, the Newcomen engine being installed on the Wheal of Fortune Mine in 1720. The success of this engine led to an increase both in depth and in extent of the workings, until it became impossible to cope with the pumping requirements by this means. At the right moment Watt brought out the modern steam engine, and the first Watt engine was erected in 1777 at Chasewater in Cornwall. It was the introduction of these improved methods of pumping which has made possible the successful development of present-day mining. Not only has the steam engine thus led to an increase in the supply of copper by enabling the opening-up of vaster deposits to be undertaken, but the development of engineering science which it has brought about has caused a further consumption of the increasing quantities of copper which it has helped to render available for use."*

The Welsh Process of Copper Smelting.

This process, although now obsolete, was, until comparatively recent times, the most important in the world. It was conducted exclusively in reverberatory furnaces of two kinds—viz., calciners and melting furnaces—and it consisted of at least six distinct operations, but more frequently seven, and sometimes eight, were required. Ores of different kinds and from different localities were generally mixed, so that the mixture contained, on an average, from 8 to 10 per cent. of copper, and was, as nearly as could be, self-fluxing. The fuel was a mixture of binding and free-burning coal burned on a bed of clinker. From time to time modifications of the process have been introduced with a view to omitting certain of the operations and shortening the process. The reactions, however, and the principles on which they depend are essentially the same. The actual problem was the extraction of copper from cupriferous ores in a quartz gangue by the joint agency of air and heat. The following is an outline of the six operations of the smelting process, of which an excellent account is given in Professor Gowland's text-book on "The Metallurgy of the Non-Ferrous Metals":—

1. *Calcination.*—This was carried out in a furnace whose hearth measured from 20 to 30 ft. in length and 10 to 12 ft. in breadth. It was designed to cause a partial elimination of sulphur, so that when the calcined ore was melted a matte consisting of about 34 per cent. of copper, 34 per cent. of iron, and the balance of sulphur and small amounts of impurities, would be obtained.

2. *First Fusion.*—This was called "running for coarse metal," and was conducted in an "ore" furnace on a silicious hearth about 13½ ft. by 9½ ft. With the calcined ore was melted "sharp" slag, from the fourth operation, which contained from 2 to 4 per cent. of copper. The ore charge of about one ton was melted and well stirred, and after being allowed to settle for a time the slag was skimmed off through the front door. Another charge was then added and the operation repeated, and after skimming off the slag, the coarse metal was tapped out through a hole in the side of the furnace. The base of the slag was ferrous silicate, but it also contained silicates of the earthy bases and of alumina. It did not carry, as a rule, more than 0·5 per cent. of copper, present as small globules of coarse metal, and was thrown away. The calcination of the ore produced a certain amount of ferric oxide, which, by reacting with unoxidised ferrous sulphide, produced ferrous oxide. Thus:—

$$3\,Fe_2O_3 + FeS = 7\,FeO + SO_2,$$

* Levy, "Modern Copper Smelting," pp. 5, 6.

and the latter combined with the silica in the charge to form fusible ferrous silicate

$$FeO + SiO_2 = FeSiO_3.$$

Some of the silica also combined with the earthy bases and alumina, and these, dissolving in the ferrous silicate, formed the slag and rendered it more fusible.

The whole of the copper—apart from that carried in the slag—united with the sulphur to form cuprous sulphide, and the balance of sulphur formed ferrous sulphide. These two sulphides dissolved, when molten, to form "coarse metal." The net result of the first two operations was thus to remove the gangue of the ore and to concentrate the copper from about 10 to 34 per cent.

3. "*Calcination*" *of the* "*Coarse Metal.*"—This was ground or granulated and then calcined, sometimes in a reverberatory, sometimes in a Gerstenhöfer, furnace, where the sulphur dioxide could be utilised for the manufacture of sulphuric acid. In this operation further oxidation of copper, iron, and sulphur was brought about.

4. *Second Fusion* (called "running for metal"). —This did not mean metallic copper, but a "regulus" or "matte" of cuprous sulphide. The charge here consisted of about 2·5 tons of calcined coarse metal together with slags from the fifth and sixth operations, both of which were rich in cuprous oxide and cuprous silicate and also with oxidised ores. After melting and skimming of the slag the regulus was tapped out into sand-moulds. Occasionally it was free, or almost free, from iron, and corresponded to "white metal," Cu_2S ($Cu = 80$ per cent.). Usually, however, it contained not more than from 70 to 75 per cent. of copper. If sufficient oxidised ores were unavailable a regulus called "blue metal" resulted, containing from 55 to 60 per cent. of copper, and this required an extra operation. The slag which resulted in this process was called "metal" or "sharp" slag. It was essentially ferrous silicate containing between 2 and 4 per cent. of copper. In this operation the following reactions occurred :—

$$Cu_2O + FeS = Cu_2S + FeO.$$
$$Cu_2SiO_3 + FeS = Cu_2S + FeSiO_3.$$

Silica required for slagging the ferrous oxide was obtained either from the slags and ores, or the furnace hearth.

5. *Roasting to Blister Copper.*—A charge of from 3 to 5 tons of white metal was melted down in a furnace of the same type as that used in operations Nos. 2 and 4, except that it had a port-hole on each side of the fire-bridge and one or more openings in the roof over the fire-bridge for the admission of air. The white metal was piled up in lumps near the fire-bridge, the port-holes were left open, and the firing so regulated that it only melted slowly and trickled down in drops so as to create the conditions for maximum oxidation. When it was melted the slag was skimmed off in order to expose a fresh surface of the matte to oxidation. In this way another layer of slag formed and was, in due course, skimmed off, and these two operations repeated several times. After each skimming the bath was allowed to cool somewhat so that it might "work" or "boil," when sulphur dioxide was expelled vigorously, and the following reactions occurred :—

$$Cu_2S + 3O = Cu_2O + SO_2.$$
$$Cu_2S + 2Cu_2O = 6\,Cu + SO_2.$$

In this way, provided the proper proportion between cuprous sulphide and cuprous oxide was maintained, the whole of the regulus was converted into metallic copper. When the charge was quiet the temperature of the furnace was raised, the slag skimmed off, and the copper tapped into sand-moulds. The complete operation occupied about twenty-four hours, but it depended greatly on the amount of iron and other impurities present. The product was "blister" copper, so called from blisters produced on its upper surface by the escape of sulphur dioxide at the moment of solidification of the metal. The slag was called "roaster" slag, and was essentially a copper iron silicate containing some cuprous oxide and even metallic copper. The percentage of copper in it varied according to the stage of the operation at which it was skimmed. It ran up to no less than about 35 per cent. in the final stages. As mentioned, these slags were sent back to, and treated in, the fourth operation.

6. *Refining.*—The blister copper thus obtained contains a number of impurities. Sulphur, iron, lead, arsenic, and antimony are nearly always present. Selenium, tellurium, zinc, nickel, and cobalt are also liable to occur. Silver is always present and generally gold, and these two metals often occur in quantities that repay extraction. The object of refining—which is also effected in a reverberatory furnace—is to remove these impurities as far as possible and to cast the purified copper into shapes suitable for the manufacture of sheets, tubes, plates, etc., and into ingots for conversion into alloys. At the present day nearly all commercial copper is

refined by a combination of reverberatory furnace and electrolytic treatment, but, for the above purposes, the manufacture of copper refined only in the furnace is still a considerable industry, especially in Wales and the north-west of England. Only the briefest outline of the process can be attempted. In this country the furnaces are of moderate dimensions, the charge being from 20 to 25 tons, since it is found that they lend themselves best to keeping the copper at a "pitch" suitable for castings which have to undergo severe mechanical treatment. The hearth is of ganister or silicious sand, and the sides of the best silica brick. The coal must be free-burning and give a long flame, and it should contain as little sulphur as possible, for copper, when refined, readily absorbs SO_2. The blister pigs are piled up as high as practicable, especially near the fire-bridge, till they fill the furnace from bed to roof. The fire is then made up and the metal rapidly heated until it begins to melt. The port-holes in the roof are then opened and air is allowed to enter freely, the temperature is maintained, and the charge thus melts down and is well oxidised. The bath is then skimmed and freely exposed to the air, and the treatment continued until it contains about 6 per cent. of cuprous oxide. This is aided either by "flapping" or by forcing compressed air either on to the surface of the copper or below it. The test as to when sulphur has been sufficiently expelled is carried out by taking a small quantity known as the "seal," "proof," or "button" sample in a small iron ladle and observing what happens on solidification. If the surface rises, sulphur is still present, and the metal must be further oxidised; if it does not rise about 14 lb. are taken in a large ladle and allowed to freeze. If this rises rabbling is resumed and continued until the large sample not only does not rise on freezing, but actually falls. This is called a "set" and the metal "set-copper." It is then very brittle, owing to the presence of the 6 per cent. of cuprous oxide. After the bath has been skimmed the fracture of a sample is examined, and gives a very good indication of the degree of oxidation which has occurred. It is then reduced by adding anthracite or charcoal and some large logs of green wood, closing up the furnace and filling the fireplace with coal. After some thirty to forty minutes the door is opened and the metal tested for toughness. If the refiner has correctly estimated the number of logs required the copper will generally be nearly tough. A few more logs are then added, and the metal "poled" with a long thick pole of green wood until a test sample freezes in the desired manner. If the surface is depressed and the colour of the fracture brick-red, the copper is "dry," and requires more poling. If, however, it is flat and the fracture salmon-coloured and silky in texture the copper is at "tough pitch." When this is the case an ingot is cast and one end is forged hot down to a thin edge, cooled in water, and the edge turned over and hammered flat. No cracks must be visible. If the tests are satisfactory the metal can then be cast either into copper or iron moulds.

When the crude copper contains arsenic and antimony in quantities exceeding those ordinarily present, caustic soda and lime are added repeatedly towards the end of the rabbling stage, until the so-called yellow metal test gives a satisfactory result. In this case the copper is alloyed with zinc so as to produce the 60 : 40 brass, and this is cast in an iron mould giving a square cake 4 by 4 in., 1 in. thick. This is allowed to cool, is nicked, and then broken under a steam-hammer, and from the type of fracture produced the degree to which the impurities have been eliminated can be judged. The products of the refinery are tough refined copper and refinery slag. The former contains upwards of 99·5 per cent. of copper, and the latter anything from 20 to 50 per cent. of the metal present, either as such or as oxide or silicate. The slag also contains the impurities present in the crude copper, except such as have been volatilised.

A special variety of tough refined copper is that cast for the manufacture of locomotive fire-box plates. These contain from 0·3 to 0·6 per cent. of arsenic. In this case the copper is first refined in the manner just described, and then the arsenic is added, either as metal or as the oxide As_4O_6 mixed with charcoal.

The refining process can be divided into two stages. The first is one of oxidation, in which the impurities, most of which have a stronger affinity for oxygen than copper, are oxidised together with much of the copper. Sulphur is completely oxidised and volatilised as SO_2. The oxidation of arsenic and antimony is never quite complete, and traces of these metals remain in the refined copper. The oxidation of bismuth, selenium and tellenium, is much less complete. Iron is oxidised and passes into the slag. The second stage is one of reduction, and its object is to reduce the cuprous oxide formed in the first stage to the metallic state. However, the reduction must not be complete,

or the metal will be brittle. In spite of the length of time that this process has been worked, and of the number of researches undertaken with the object of determining how the cuprous oxide acts, it cannot be said that a complete explanation is even now forthcoming. The view most generally held is that the oxides of the foreign metals present in the copper are not injurious so long as they remain oxides, and that they are only harmful when reduced to the metallic state, and that the presence of some cuprous oxide tends to keep them in the oxidised condition.

The "direct" process of copper-refining devised by Nichols and James at the Cape Copper Company's works at Briton Ferry, is an ingenious modification of the Welsh process. It was successful in eliminating the operation of roasting white metal to blister copper.

A brief reference to "best selected copper" is necessary. The process by which this variety of copper was made, was devised at Swansea about the beginning of the eighteenth century. Its object was to prepare pure copper from Cornish ores containing tin. To-day it is no longer, or hardly ever, applied to this purpose; but it survives, and is used in the extraction of gold from white metal, and the term "best selected" is still applied to refined copper of special purity. The white metal is roasted so as to produce a partial reduction to copper, and the product is skimmed and tapped out into moulds. There it separates into two layers. The lower consists of metallic copper, and, if the operation has been properly conducted, carries all the gold, part of the silver, nearly all the tin, and much of the arsenic and antimony. These are called "bottoms," and from them recovery of the gold and silver is possible. The upper layer consists of white metal which can be refined in the ordinary way, and yields an unusually pure furnace-refined copper. This is the "best selected" copper of to-day. It may contain up to 99·7 per cent. of the metal.

The foregoing is a brief account of the processes which made South Wales famous for so many years in the history of copper-smelting and refining, and it is no exaggeration to say that they constitute some of the finest examples of skilled metallurgical art with which we are acquainted, especially when the times and working conditions are borne in mind.

In Great Britain the position to-day with regard to copper metallurgy is briefly as follows:—

The actual smelting of copper is a very small industry, and in recent years the few smelters who do exist have found it more and more difficult to obtain smelting materials. The United States of America largely influences the price of copper—I am speaking of the situation before the war—and the policy pursued there is to attract smelting materials from other countries for treatment. The American can afford to pay a high price for imported ores, because the remainder of his raw material is produced at home at a price which is so low that a low average selling price for the whole serves to secure an adequate profit. In the United Kingdom only a few of the large copper manufacturing firms, and one or two companies owning mines abroad, can afford to run smelting works under these conditions.

On the other hand, a large number of manufacturers, not actual smelters of copper from the ore or matte, are engaged in refining Blister, Bessemer, or other varieties of crude metallic copper, and in producing the "tough" and "best selected" brands of the metal. The tough quality is used chiefly by the engineering and shipbuilding industries, and is specified by the Engineering Standards Committee. A variety of this, which is made almost exclusively in this country, is the tough pitch arsenical copper containing about 0·4 per cent. of arsenic. This has a very extended application. The best selected quality is generally made in the form of ingots, and is used for the manufacture of brass and other alloys.

These varieties are for the most part furnace-refined, and I think I am correct in saying that in the production of this class of material our works in this country are pre-eminent. Much the greater part of the copper produced to-day, however, is electrolytically refined. In the United Kingdom the amount of copper treated in this way is very small, and only some half-dozen firms are engaged in this operation. In recent years several firms have discarded their plant, simply because they found that they could not compete commercially with America.

The whole question of the future of the copper-smelting and refining industries in this country is being considered by the Non-ferrous Metal Trades Committee of the Board of Trade, under the chairmanship of Sir Gerard Muntz. It is one of the highest importance. Until this report is published and made available, as I hope it will be, it would be improper to offer any further observation on the situation which exists to-day.

CONDEMNED ARMY BOOTS.

A paper by Mr. M. C. Lamb, in the *Journal of the Society of Chemical Industry*, gives some interesting information about the various methods that have been suggested for making use of the leather in condemned Army boots. Waste boot-leather has been found to be a good road-making material, the scrap leather being mixed in proportions varying from 5 to 10 per cent. with slag, granite or limestone, in conjunction with asphalt and bitumen. This mixture, known as "Broughite," from the name of its patentee, is claimed to possess the hardness and rigidity of a tar macadam road, with less attrition and dust and greater resilience. The method adopted is to lay the surface of the road with the composition, and give a top facing of slag, granite or limestone. One ton of the tarred material is needed to cover six square yards with an application four inches thick, or some 89,000 pairs of discarded boots to each mile of roadway eight yards wide.

"Broughite" appears to be a cheap and satisfactory substitute for wood-paving; it wears better, is equally silent, costs less than wood and no more than bituminous macadam. It affords a good grip for rubber tyres and an excellent foothold for horses. The Roads Board is making trials of its value, and several pieces of roadway have been laid down under its direction.

Waste leather makes an admirable form of animal charcoal. When subjected to destructive distillation, leather yields about a fourth of its weight of a comparatively pure charcoal, which has a decolorising power, as tested on sugar syrups and gelatin, in no wise inferior to bone-char. At the same time, the distillation products afford from 23 to 25 per cent. of crude ammonium sulphate, suitable as a fertiliser.

The leather of boot uppers contains on an average about 15 per cent. of extractable grease and fatty matter, melting at about 38° C., and quite suitable for currying leather, and for other purposes in which a moderately hard low-grade grease suffices. The approximate present value of these products to be obtained from a ton, or 560 pairs, of condemned boots is rather more than £16 11s., of which the charcoal and ammonium sulphate are by far the more important items.

On account of its nitrogen content, leather waste is regarded as possessing considerable potential value as a manure. It, however, decomposes very slowly, and requires special treatment to make it effective. Chrome-tanned material is found to be hurtful to plant-life.

Other uses for condemned military boots are in the manufacture of leather board, leather pulp and powder, clogs, washers for screw-down water-taps, mats, cyanides and prussiates, glue and size.

OBITUARY.

SIR WILLIAM HEERLEIN LINDLEY, M.Inst.C.E.—Sir William Heerlein Lindley, who had been a member of the Royal Society of Arts since 1902, died suddenly at Putney on December 30th, 1917.

Born in 1853, and educated at Blackheath, he began his professional career in 1870, by acting as resident engineer for his father on the waterworks at Budapest. Three years later he became engineer to the city of Frankfurt-on-Main, where for over twenty years he was in charge of all branches of municipal engineering, and of the regulation of the Main. He was also concerned with the electricity supply works at Elberfeld; with sewage works at Elberfeld, Homburg, Mannheim, Wurzburg, Prague, and Cracow; and with water-supply at Warsaw, Bukarest, Cracow, and Baku. At the last-named town he designed and constructed new works, by which water is brought from the Caucasus over a distance of 112 miles.

Sir William Lindley was President of the Engineering Standards Commission of the German Gas and Waterworks Engineers, and of the commission on stray electric currents from tramways. He was knighted in 1911, in recognition of the services which he rendered to the Royal Commission on Canals and Waterways, for which he prepared reports on the waterways of France, Belgium, Germany, and Holland.

GEORGE CLIFFORD WHITWORTH, I.C.S. (retired).—Mr. George Clifford Whitworth died at Grasse, Alpes Maritimes, France, on December 17th, 1917, aged seventy-one. Son of the late Rev. W. Whitworth, incumbent of Little Leigh, Cheshire, he was educated at Sandicroft School, Northwich, and Queen's College, Liverpool, and passed the Indian Civil Service examination in 1867. He served in the Bombay Presidency from 1869 to 1904, the principal posts successively filled by him being Judicial Assistant to the Political Agent in Kathiawar, Acting Secretary to Government, Judicial Commissioner in Sind, Judge and Legal Remembrancer, Additional Member of the Viceroy's Legislative Council (1902), and Judge and Session Judge. He was the author of "The Theory of Relevancy for the Purpose of Judicial Evidence," an "Anglo-Indian Dictionary," and other works. He joined the Society in 1906, and frequently attended the meetings of the Indian Section before he went to reside in the South of France, a few years ago.

GENERAL NOTES.

DISTILLATION OF ESSENTIAL OILS IN INDIA.—Part VIII. of Vol. V. of the official "Indian Forest Records" (Calcutta) contains notes on certain essential oils by the Chemical Adviser to the Forest Research Institute, Dehra Dun. The notes deal with (1) the Eucalyptus Oil Industry in the

Nilgiris; (2) the Distillation of Geranium Oil in the Nilgiris; and (3) the Manufacture of Wintergreen Oil in India. The writer, being impressed with the anomalous fact that, notwithstanding the immense plantations of *Eucalyptus globulus* which exist in the Nilgiris, and the simplicity of the distillation of the essential oil from the leaves, large quantities of this oil should continue to be imported into British India from Australia, proceeded to investigate the question on the spot, and he embodies in his report suggestions for materially reducing the cost of production. An important factor in this reduction is the adoption of a certain form of still, diagrams of which are included in the report. While carrying out experiments in connection with the above-mentioned investigation into the distillation of eucalyptus, the writer also investigated the possibilities of the cultivation of the geranium, which is abundant in the Nilgiris, and the distillation of oil therefrom. He suggests that its distillation could be combined with that of eucalyptus oil without incurring any additional expenditure on outlay, supervision, etc. With regard to the inquiry into the distillation of wintergreen oil (*Methyl salicylate*), the writer concludes that this promises to be a profitable industry in Assam, provided adequate arrangements are made to cultivate the plant. The Nilgiri plant is too poor in oil-content to be considered as a commercial source of *Gaultheria* oil. The above-mentioned publication, which is illustrated by photographs, may be consulted by British firms interested at the Department of Commercial Intelligence, 73, Basinghall Street, London, E.C. 2.

Sugar-cane Wax.—A considerable amount of attention has been given in recent years to the recovery of wax from the waste produced in the extraction of sugar from the sugar-cane, and it is satisfactory to find that this industry has now been started on a small scale in Natal. Samples of the first consignment of Natal sugar-cane wax shipped to this country have been examined at the Imperial Institute, and found to be of good quality, quite equal to that of the first trial samples made and examined. Sugar-cane wax is now becoming better known on the market, and could be used as a substitute for the better known Carnauba wax in the manufacture of gramophone records, polishes, candles, etc.

Increased Printing Charges. — A report received by the London Master Printers from the London Costing Committee states that the total increase in charges for printing since the outbreak of war amounts to 60 per cent., in addition to the increased cost of materials—paper, 200–400 per cent.; ink, 50–200 per cent.; strawboards, 300–400 per cent.; millboards, 150 per cent.; glue, 200 per cent.; cloth, 100 per cent.; and leather, 75–125 per cent.

Fertilisers. — Sir Richard Winfrey, Parliamentary Secretary to the Board of Agriculture, replying to a question in the House of Commons, said: The output of basic slag during the year ending May 31st, 1918, will amount to at least 500,000 tons, as compared with something under 400,000 tons in the preceding season. In addition, certain accumulations of low-grade slag which have not hitherto been regarded as sufficiently valuable to be used will be ground for use if required. The supply of sulphate of ammonia for agricultural purposes is likely to amount to 190,000 tons during the present season, as against 150,000 tons last year. All possible steps were being taken to extend the output.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

January 16. — Reginald S. Clay, D.Sc., Principal of the Northern Polytechnic Institute, "The British Pianoforte Industry."

January 23. — Alexander Newlands, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in Great Britain (with special reference to Scotland): its Amount and Economic Value."

January 30.—Sir William George Watson, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." Sir Arthur D. Steel-Maitland, Bt., M.P., will preside.

February 6.—Wm. Frecheville, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of Mineral Resources of the Empire." Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

February 13.—Lord Leverhulme, "The Relations between Capital and Labour — Reasonable Hours, Co-partnership, and Efficiency." W. A. Appleton, C.B.E., Secretary of the General Federation of Trade Unions, will preside.

February 20.—Maurice B. Adams, F.R.I.B.A., "Picturesque Architecture." Sir Aston Webb, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

February 27.—Sir William H. Clark, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The Right Hon. Lord Faringdon will preside.

March 6. — A. H. Paterson, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace."

The Right Hon. Frederick Huth Jackson will preside.

March 20. — Frank Stuart Courtney, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." Sir John Snell, M.Inst.C.E., will preside.

Dates to be hereafter announced:—

Major Sir Robert Armstrong Jones, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War."

Martin O. Forster, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

George Martineau, C.B., "Sugar from several Points of View."

John B. Farmer, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. Lawrence Ball, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

Indian Section.

Thursday afternoons, at 4.30 p.m.:—

January 17.—H. M. Surtees Tuckwell, M.I.Mech.E., "The Tata Iron and Steel Works." The Right Hon. Lord Sydenham, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., will preside.

February 14. — Sir Henry Ledgard, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India."

March 14.—

April 18.—Alfred Dickinson, M.Inst.C.E., "Water Power in India."

May 30.—Hon. Sir Dinshaw E. Wacha, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Colonial Section.

Tuesday afternoons, at 4.30 p.m.:—

February 5.—C. du Plessis Chiappini, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

March 5.—

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

Cantor Lectures.

Monday afternoons, at 4.30 p.m. (unless otherwise announced):—

Charles R. Darling, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." Three Lectures.

Syllabus.

Lecture I.—January 21.—*Methods of Producing High Temperatures.* Special fuel furnaces—Oxy-hydrogen flame—Oxy-acetylene—Thermit—Electric furnaces.

Lecture II.—January 28.—*High Temperature Processes.* Smelting of platinum and metals of high melting-points—Welding and cutting by oxy-acetylene flame and electric arc—Thermit welding—Production of steel and other metals by electric furnaces—Fixation of atmospheric nitrogen—Metal spraying.

Lecture III.—February 4.—*Products and their Uses.* Artificial graphite for various purposes—Carborundum for abrasion and refractory purposes—Alundum and silica for chemical apparatus and refractories—Calcium carbide for making acetylene—Pure metals by thermit processes—Siloxicon and other silicon—Carbon compounds for refractories and thermal insulators—Aloxite and its uses.

Edgar Crammond, Secretary of the Liverpool Stock Exchange, "The Economic Condition of the United Kingdom before the War: The Real Cost of the War: and Economic Reconstruction." Three Lectures.

February 18, 25, March 4.

J. Young, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

Cobb Lectures.

Professor Henry R. Procter, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

Juvenile Lecture.

Wednesday afternoon, at 3 p.m.:—

P. Chalmers Mitchell, D.Sc., LL.D., F.R.S., Secretary of the Zoological Society of London, "Animal Camouflage." Lecture II.)

January 9.

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Royal Society of Arts

CANTOR LECTURES.

A full list of the Cantor Lectures which have been reprinted from the **Journal** and published separately may be obtained on application to

THE SECRETARY, John Street, Adelphi, London, W.C.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

HOWARD AND OTHER LECTURES.

Heavy Oil Engines. Four Lectures. By Captain H. Riall Sankey, R.E., M.Inst.C.E. (1912.) Price 1*s*.

Aeronautics. Three Lectures. By Prof. J. E. Petavel, D.Sc., F.R.S. (1913.) Price 1*s*.

Surface Combustion. Three Lectures. By Prof. William Arthur Bone, D.Sc., Ph.D., F.R.S. (1914.) Price 1*s*.

Motor Fuel. Three Lectures. By Prof. Vivian B. Lewes, F.I.C., F.C.S. (1915.) Price 1*s*.

Coal and its Economic Utilisation. Three Lectures. By Prof. John S. S. Brame. (1917.) Price 1*s*.

The Shortage of the Supply of Non-Phosphoric Iron Ore. Two Lectures. By Prof. William George Fearnsides, M.A., F.G.S., M.Inst.M.E. (1917.) Price 1*s*.

Journal of the Royal Society of Arts.

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FRIDAY, JANUARY 11, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 16th, at 4.30 p.m. (Ordinary Meeting.) REGINALD S. CLAY, D.Sc., Principal of the Northern Polytechnic Institute, "The British Pianoforte Industry." SIR FREDERICK BRIDGE, C.V.O., Mus.Doc., will preside.

THURSDAY, JANUARY 17th, at 4.30 p.m. (Indian Section.) H. M. SURTEES TUCKWELL, M.I.Mech.E., "The Tata Iron and Steel Works." The RIGHT HON. LORD SYDENHAM, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., will preside. The paper will be illustrated by cinematograph views.

Further particulars of the Society's meetings will be found at the end of this number.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and can be obtained by Fellows on application to the Secretary.

JUVENILE LECTURES.

On Wednesday afternoon, January 9th, Dr. P. Chalmers Mitchell, F.R.S., Secretary of the Zoological Society of London, delivered the second and final lecture of his course on "Animal Camouflage."

The lecturer said that the whole of the animal kingdom was full of patterns of the most startling kind, every part of the body, inside and outside, showing the most complicated and elaborate patterns, but nearly everywhere where the colour could be seen it was camouflaged in some way or other, in order to conceal the animals from their enemies.

It was extremely important for animals to hide their shape as much as they could, and they adopted many different ways of doing that. One of those methods was by very large and grotesque horns, such as the antlers of some kinds of deer. For example, in the case of reindeer on open plains with a background of trees, the branching horns served to hide the usual animal shape, and from a certain distance they blent with the irregular background of branches of trees, etc. The antlers also served to camouflage the animals by altering their shadow. When animals lay down and went to sleep they tried to make themselves look as unlike animals as possible by adopting various attitudes; for instance, some curled up, hiding their legs, others hung downwards from branches of trees, and birds went to sleep with one leg drawn up. A self-coloured animal became very conspicuous when the sun was shining, the upper part of it being brilliantly lit up and the lower part in shadow; and therefore it was very common for animals to be countershaded—dark above and light below in order to camouflage themselves. That method was to be seen in certain eagles, in penguins, wild donkeys, and kangaroos. Another method of camouflage was striping. It was commonly supposed that tigers were striped in order to match the jungle which they inhabited; but, as a matter of fact, tigers did not originally belong to jungles at all, but to open country much further north than the jungles of India and the tropics that they now inhabited, and their striped skin was simply a method of making them invisible by causing them to blend with the background better when seen from a distance. There were many different varieties of pattern and arrangement of the stripes, which Dr. Chalmers Mitchell illustrated by lantern-slides. In some cases the fully-grown animal, being able to protect itself when attacked, was not striped at all, whereas the young animal was. Another method by which animals concealed their shape was by being marked with a

pattern that served to break up the outline of their bodies. For instance, when the skunk was looked at from above it was clearly visible, but when looked at from underneath, in the way that the animal it was preying upon would see it, its shape was broken up by the manner in which it was marked. The lecturer concluded with a number of slides showing that in many cases animals were only camouflaged when young and incapable of protecting themselves.

On the motion of the Chairman, Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, a vote of thanks was accorded to Dr. Chalmers Mitchell for his interesting course.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROGRESS IN THE METALLURGY OF COPPER.

By H. C. H. Carpenter, M.A., Ph.D., M.Inst.M.M., A.R.S.M.,
Professor of Metallurgy, Imperial College of Science and Technology.

Lecture II.—Delivered December 10th, 1917.

According to an estimate by Brown and Turnbull* the total copper produced from mines in the United Kingdom in the nineteenth century (1801–1900) was 864,660 long tons, distributed as follows:—

Cornwall and Devon	729,500
Ireland	69,000
Anglesey and other districts	66,160

As regards Cornwall and Devon, the mining of copper dates back certainly to the reign of Queen Elizabeth. It was obtained then—though in very small quantities—from mines at Perran Sands. The district was worked almost continuously from this period until the end of the nineteenth century—*i.e.* for about three hundred years. In most cases each individual mine had only a brief life. The following table† is given as the result of an investigation of the mines of this district for a period of thirty years:—

35	mines	lasted	20 years.
40	,,	,,	10 ,,
31	,,	,,	5 ,,
114	,,	,,	less than five years.

In Ireland mining was carried on throughout the eighteenth and the greater part of the nineteenth century (until 1880). Anglesey produced copper in Roman times. Mines were opened up again in the eighteenth century, and the industry carried on well into the nineteenth century.

The production and price of the metal in decennial periods is given by Brown and Turnbull as follows:—

Period.	Output (tons).	Price (£ per ton).
1801–1810	65,000	160
1811–1820	73,400	130
1821–1830	109,900	101
1831–1840	144,000	94
1841–1850	138,200	88
1851–1860	142,200	111
1861–1870	116,300	87
1871–1880	48,700	79
1881–1890	21,300	60
1891–1900	5,660	55

From this it is clear that the copper-smelting industry based on home ores underwent a great expansion in the period 1821–30; that it reached its zenith in the next decade, and maintained this with slight fluctuations for about thirty years; that between 1861 and 1870 a decline set in which was greatly accentuated in the succeeding decade, and that in the final period the production was less than one-tenth what it had been in the opening decade. Let us briefly examine the history of the industry in these periods. Although, as I have mentioned, the chief seat was in South Wales, ores were also smelted and refined in the Midlands, South Lancashire, and Yorkshire.

The expansion in 1821–30 was due primarily to the use of steam-hauling and pumping machinery in the Cornish mines, which enabled them to be worked to greater depths than before. Even at this time mining at a depth of 1,800 ft. was considered a great achievement. In the next decade foreign ores began to be imported into the United Kingdom, notably from Chile, and in the succeeding decade production began in the United States of America with a yield of 100 tons in the year 1845. Mining operations were begun in South Australia at the Kapunda and Burra-Burra properties, the ores being chiefly oxides. There was also a considerable amount of copper ore mined in Cuba.

* "A Century of Copper," p. 24.

† Hunt's "British Mining," p. 830.

Notwithstanding the great increase in production of this period, the metal was readily absorbed in the engineering and allied industries. In particular, copper and yellow metal were extensively applied to the sheathing of wooden ships. Most of the world's copper was sent to be refined at Swansea during this period; but from this time onwards the British copper-mining industry commenced to decline and Swansea became to a greater and greater extent dependent on foreign sources of ore. It was this development of foreign supplies and the unsatisfactory treatment which the producers received at the hands of the smelters which was the cause of the eventual displacement of Swansea from its position as the chief seat of manufacture.

From 1851 to 1860 was the critical decade. Early in the nineteenth century there was formed the Associated Copper Smelters at Swansea. On the authority of Brown and Turnbull it may be stated that it was designed "on the one hand for the purpose of keeping the prices of copper ore and regulus low; and, on the other hand, of keeping up the selling price of tough and other kinds of copper." This was a very favourable period for its operations, as there was abundance of copper ore to be had cheaply, and a great demand for the metal was growing up in the engineering trade. These large additional sources of supply made the Swansea smelters very independent and difficult to deal with. The *modus operandi* of the Association was to arrange a day in Swansea when the different parcels of ore were put in and ticketed, and these days were called the "Swansea Ticketings." Each smelter bid for the ore he required at his own price. It was supposed that there was a competition going on amongst the smelters, but practically there was none, as they largely agreed among themselves what they would pay for each class of ore and regulus. Chile had by now become the most important producer. In those days the ore was always carried in sailing ships, which, owing to their being wind-propelled, did not arrive with the regularity since accomplished by steamers, and many ships were thus, with a change of wind, brought to port on the same day. The smelters, watching these collective arrivals, regulated their prices for ore in anticipation of the ticketings, and so secured large profits subsequently by raising the "Associated" price for the metal when the operation was completed. In this way they sold, at a high price, the copper which they had obtained at a low price by their combination. The Swansea smelters thus forced the mine-owners to seek a remedy, and this they did by smelting the ore either at or near the mines and exporting the metal instead of the ore. In 1842 Lambert introduced reverberatory furnaces into Chile, and they were so successful that in a short time they were in use throughout the country. In 1857 he erected the first blast furnace there, and the smelting industry then grew so rapidly that, whereas in the period 1856–65 the exports were in the proportion—ore 21·5 per cent., regulus 38 per cent., and bars 40·5 per cent.; in the period 1886–95 they were, ore 1·5 per cent., regulus 3·5 per cent., and bars 95 per cent. The ultimate effect was to widen the market for the finished Chilian product, and Continental purchasers were thus enabled to obtain their supplies of metal direct, instead of being obliged to purchase from the Welsh smelters on the unsatisfactory terms then prevailing. The rise of Chile as a producer of copper is evidenced by the following figures:—

Decade.	Production (tons).
1831–1840	45,000
1841–1850	88,100
1851–1860	214,500
1861–1870	447,400
1871–1880	483,300

In the decade 1861–70 Chile definitely took the lead as the world's greatest producer, contributing about half the total manufactured. This period is also memorable in that it witnessed great developments in mining at Calumet in the Lake Superior District, U.S.A., where the copper occurs native in quantities varying, on an average, from about 1 to 3 per cent. in the ore-body. Percy states that in 1858 no less than 6,000 tons of copper were produced from this district alone. The ore is of three kinds, in each of which, however, the copper occurs native: (1) Vein deposits, consisting of enormous masses of copper; (2) the conglomerate, in which the metal is tolerably evenly distributed, and mostly in a fine state of division in the rock, the latter being very hard; (3) the amygdaloid, in which the metal is highly segregated, and is found replacing other minerals. Some of the copper aggregates in the vein deposits are very large. Percy mentions that in 1854 not fewer than forty men were engaged during twelve months in cutting up a single mass of native copper weighing about 500 tons. Native copper

is generally remarkable for its toughness. A specimen from Chile, about three-eighths of an inch in thickness, is instanced by him as having been bent backwards and forwards forty-eight times before breaking.

The special feature of the next decade was the entry of Spain and Portugal as large producers of the metal from cupreous pyrites. Chile maintained its increased production, and increases came from Australia and the United States of America. The Spanish and Portuguese industry had its origin in the following circumstances described by Mr. Gossage, in a paper read at the British Association in Manchester in 1861. A French trading company in Marseilles persuaded the King of Sicily that his revenue would be improved if he granted them a monopoly of the export of sulphur. The effect of this was that the price advanced from its original figure of £5 to £14 per ton. It was then discovered that our own Cornish mines, and especially those in co. Wicklow, Ireland, constituted an available source of sulphur of great value, and chemists quickly devised methods of converting this into sulphuric acid. The King of Sicily thus conferred a great boon on this country, since his monopoly was destroyed and considerable sums of money were beneficially circulated both in Cornwall and Ireland. The supply in these districts lasted from about 1840 to 1860, but at the end of this period was quite insufficient for the demand. New sources were then found in Andalusia in Spain, and the adjoining districts in Portugal, and in succeeding decades these furnished notable quantities, not only of sulphur, but also copper and iron. The San Domingo and Tharsis Mines were reopened and passed under English management, and in 1876 the Rio Tinto Company of London took over the working of the famous mine of that name from the Spanish Government, and has continued to work it ever since.

This copper or cupreous pyrites is, in most cases, used first of all as a source of sulphur for sulphuric acid in the manufacture of sodium carbonate. In the early days of its use the residues were thrown out as waste. About 1862, however, the Henderson process for extracting the copper by a wet method from the burnt ore was invented and proved successful, and thereafter these residues were sold to copper smelters and had their copper extracted. The residue from this process left the iron in the form of ferric oxide containing a trace of copper, and was known as "purple ore" or "blue billy." This was sold to iron puddlers and was used by them for lining the hearths of their furnaces, and in this way most of the iron was converted into metal. The ore thus became valuable as a source of its three chief constituents—sulphur, copper, and iron. The production of copper from Spanish and Portuguese sources is shown in the following table:—

Decade.	Production (tons).
1841–1850	3,850
1851–1860	24,700
1861–1870	80,900
1871–1880	195,900
1881–1890	482,900
1891–1900	537,300

The treatment of the Rio Tinto ore deserves special mention. It is a massive cupriferous pyrites containing up to 3 per cent. of copper. It is used as a source of copper in the first instance, and it is the best known and, until lately, so far as I know, has been the only large-scale example of the extraction of the metal from its ore by wet methods. The process consists in allowing huge heaps of the mineral to oxidise in the air, in washing out the copper sulphate formed by water, and precipitating the copper from the solution by metallic iron. The fact that this procedure can be, and is, commercially successful is due fundamentally to the fact that the copper exists in a particular state of combination in the ore. When copper occurs as chalcopyrite, $CuFeS_2$, it does not oxidise by mere exposure to the air. In the form of covellite, CuS, oxidation proceeds very slowly. In the case of chalcocite, Cu_2S, however, the oxidation reaches a much higher rate. The bulk of the Rio Tinto ore is chalcocite. When the mineral is exposed freely to air and moisture the following reactions occur.

1. Some iron pyrites are oxidised:—

(*a*) $FeS_2 + 7\,O + H_2O = FeSO_4 + H_2SO_4$.

2. The ferrous sulphate is readily oxidised to ferric sulphate:—

(*b*) $2\,FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O$.

3. The double decomposition between the ferric sulphate and the sulphides of copper renders the latter soluble:—

(*c*) $Fe_2(SO_4)_3 + Cu_2S = CuSO_4 + 2\,FeSO_4 + CuS$.

(*d*) $Fe_2(SO_4)_3 + CuS + 3\,O + H_2O = CuSO_4 + 2\,FeSO_4 + H_2SO_4$.

Reaction (*c*) causes half the copper to go into

solution in a few months, whereas it takes about two years to dissolve 80 per cent. of the remaining half of the copper.

The following is an outline of the process, of which a full account is given in the *Transactions* of the American Institute of Mining Engineers, 1904. A site is chosen where the ground is impervious to liquids, and slopes so as to enable the copper liquor to collect and run out at the base of the heap. A network of air flues on the ground, about twelve inches square, made of rough stones is first made and then a number of vertical chimneys, fifty feet apart, are built in the same manner while the heap is being made and are connected with the ground flues. The ore is broken down to lumps of from two to three inches diameter. The coarse and fine products are built into a pile of about thirty feet in height, the upper surface being kept level. The heap contains about 100,000 tons of ore. Its top surface is formed into squares by means of ridges, so that water can be run over it in order to ensure that all parts are equally washed. Oxidation starts rapidly and the temperature in the flues rises to from 77° to 82° C. Care is needed to prevent the heap catching fire. When oxidation has proceeded sufficiently far, water is run on until soluble copper salts have been extracted. Oxidation is then allowed to begin again and the process repeated. After the lapse of a year the surface requires "retilling," and the squares are arranged in different positions. When the copper content is reduced to 0·3 per cent. the process is discontinued. The residue is exported as "washed sulphur ore" and sold to sulphuric acid manufacturers.

The copper liquor, as it runs from the heap, contains some ferric iron in solution, which is removed by passing it over a small heap of fresh ore which reduces ferric to ferrous iron—$7\,Fe_2(SO_4)_3 + FeS_2 + 8\,H_2O = 15\,FeSO_4 + 8\,H_2SO_4$. This reaction is completed in a reservoir formed by a masonry dam across a small ravine, and here the liquor remains until it is drawn off to the precipitating vats. As it enters these it contains about 0·4 per cent. of copper, 0·1 per cent. Fe_2O_3, 2 per cent FeO, 0·03 per cent. arsenic, and about 1 per cent. free sulphuric acid. The liquor is run through long trough-like precipitation vats over pig-iron, which throws down the copper as "cement" or "precipitate." These are arranged on the slope of a hill, and the solution passes backwards and forwards through them until it is discharged free from copper. The vats are of wood, and vary from 200 to 400 feet in length. Some of them are cut out from the series and cleaned daily, and the "cement" is removed and taken to the cleaning and concentrating plant.

Containing, as it does, about 70 per cent. of copper, it is thrown a little at a time on to a perforated copper plate placed at the head of a long launder, and is washed through it by a strong jet of water. The material which does not pass through consists of leaf-copper and small pieces of iron. This is thrown into a heap and sorted to remove the iron. The precipitate which passes into the launder is turned over against the stream of water and concentration effected in this way. It is divided into three grades: "No. 1 precipitate," which collects in the first few yards of the launder, is the purest, and contains about 94 per cent. of copper and not more than 0·3 per cent. of arsenic. Following this is "No. 2 precipitate," containing about 92 per cent. of copper and 0·75 per cent. of arsenic. Still lower down comes "No. 3 precipitate," containing only about 50 per cent. of copper and arsenic up to 5 per cent., together with graphite from the pig iron and antimony and bismuth from the liquors. Nos. 1 and 2 are shipped for refining in this country, while No. 3 is compressed into balls and sent to the blast furnaces.

It was in the next decade, 1881–90, that the United States of America rose to the position of the world's greatest producer, and contributed about one-third of the total supply. The Lake Mines expanded their output, and both the Montana and Arizona properties were opened up and made large contributions. Spain and Portugal increased their output considerably, and in 1890 the Rio Tinto Company alone produced 30,000 tons. It was in this period also that ancient methods of production were superseded in Japan and modern processes introduced, in consequence of which that country became an exporter of copper. The credit for this is due to Professor (then Mr.) Gowland, who went out from this country and erected modern smelting plant in Japan. The decline of Chile also dates from this decade, due to the exhaustion of the richer oxide ores which were once so abundant. Much the same thing happened in South Australia. This decade was also notable for the attempt of M. Secretan, of the Société des Métaux, Paris, to obtain complete control of the output and price of copper, which failed in the spring of 1889, when the price fell £35 per ton in one day.

In the next decade, 1891–1900, American

supremacy was clearly established, and that country produced more than 50 per cent. of the world's copper. Very large increases of output took place at the Lake Montana and Arizona mines; and other districts, of which Utah was the most important, became producers. The rise and progress of the United States of America is set forth in the following table:—

Decade.	Production (tons).
1841–1850	2,400
1851–1860	37,000
1861–1870	97,100
1871–1880	186,400
1881–1890	730,700
1891–1900	1,939,940

In the final decade of the nineteenth century that country produced nearly twice as much copper as in the previous half century. The strong position established by it at the end of the nineteenth century has not only been maintained, but improved during the opening years of the twentieth century, as the following table, showing estimates of the world's smelter production in 1912, proves:—

SMELTER PRODUCTION.*

Country.	Metric tons.
United States of America	592,400
Japan	67,000
British Isles	63,200
Australia	44,900
Mexico	44,000
Germany	39,800
South America	35,000
Russia	33,500
Chile	25,000
Spain	23,300
Canada	15,500
France	13,200
Europe (other countries)	10,900
Serbia	7,400
Austria-Hungary	4,000
Italy	1,700
Total	1,020,800

Moreover, the greatly increased demand for copper created by the war has been principally met by the United States smelters and refineries which, in 1916, produced no less than about 865,000 long tons.†

Before dealing with the industry as it exists in that country to-day, a few words are necessary as to the consumption of the metal. In all some ten million tons were produced and consumed in the nineteenth century. In the early years of this period the bulk of the metal was absorbed in the engineering and shipbuilding industries, in railways, steamers, and in the applications of steam power. Later on came its use as a sheathing of wooden ships, either in the form of copper or yellow metal. The principal increase in production came, however, in the last decade, and this was due predominantly to the discovery of the dynamo and the demand for copper in the electrical industry. It is estimated that this industry absorbed then, and continues to absorb, about two-thirds of the entire copper produced. The metal is specially prepared and sold under the designation "high conductivity copper," and in its manufacture electrolytic refining followed by furnace refining is necessary in order to obtain the requisite electrical conductivity and mechanical properties. The demand for electrical purposes continues to increase, and has not been affected by the advance in prices, as hitherto there has been no substitute for copper for these purposes at anything approaching its pre-war price. In fact, as the following table shows, the tendency throughout the century which has been reviewed, apart from the decade when the Associated Smelters of Swansea controlled the price, has been to fall:—

AVERAGE PRICES OF ENGLISH TOUGH COPPER.*

Period.	Price per ton.	Period.	Price per ton.
1801–1810	£160	1851–1860	£111
1811–1820	130	1861–1870	87
1821–1830	101	1871–1880	79
1831–1840	94	1881–1890	60
1841–1850	88	1891–1900	55

It must be mentioned, however, that the price of copper has been greatly influenced by financial speculation, so that, until recent times, it has fluctuated considerably from year to year. The price of electrolytic copper has usually been from £2 to £4 per ton lower, and that of standard copper from £3 to £6 per ton lower than that of the best selected metal.

With regard to improvements in the technique of copper smelting and refining the following

* "Copper Handbook." Weed. 1915.

† Estimated by the *Metal Bulletin*.

* "A Century of Copper," p. 1.

were the more important of the advances down to the year 1880 :—

1. *In Roasting Practice.*—In 1865 the mechanically driven furnace (the Brückner cylinder) was introduced, but it was not applied to copper smelting until many years afterwards. Still later came the application of roaster gases for the manufacture of sulphuric acid.

2. *In Blast Furnace Smelting.*—Rachette, in Germany in 1863, introduced the elliptical blast furnace in connection with lead smelting. It was rapidly adapted to copper matte smelting. In 1875 the Piltz water-jacketed furnace was employed, likewise in lead smelting, and subsequently adapted to copper smelting. Although this method was found to lead to great improvements in the working of furnaces, its application was restricted for some time by practical difficulties. Ultimately the highest degree of success was obtained in America, where the plan of working elongated furnaces with water jackets was adopted.

These improvements were made on the Continent.

3. *The Principle of Pyritic Smelting.*—In 1878 John Hollway, an Englishman, conducted an elaborate series of tests with Rio Tinto ore at Penistone, the results of which were communicated to this Society in February, 1879, in a remarkable paper, entitled "A New Application of Bessemer's Method of Rapid Oxidation by which Sulphides are Utilised for Fuel." Somewhat earlier a Russian engineer, Semenikow, had been led by a consideration of the principles of the Bessemer process to utilise the heat produced by the oxidation of the sulphides in the treatment of copper mattes, but Hollway was the first to conceive the idea of what is called raw sulphide or pyritic smelting, and in his paper he enunciates clearly the principles underlying the process, and gives an account of the experimental data which support them. Professor Gowland, in his presidential address to the Institution of Mining and Metallurgy in 1907, has dealt fully with this matter, and what he says is: "England deserves the credit of the invention of pyritic smelting, although America was the first to make the invention a practical success." Between them, Semenikow and Hollway made the most important metallurgical discovery of the century in regard to copper smelting. Let me give a brief quotation from Hollway's paper, which puts in a concise form the far-reaching nature of the revolution in smelting methods proposed by him. He says: "When metals are extracted from their ores by fusion the necessary heat is always obtained by the burning of coal, coke, or other form of carbon. I wish, however, to remind you that sulphides can be made to burn in air and are thus combustible substances, while the oxides are bodies that have been already burned, which, as you know, is the conventional expression for entering into combination with oxygen. The metallic sulphides consequently are natural combustible minerals, and my object is to prove that they can be utilised as sources of heat in certain metallurgical operations.

"The most important of the mineral sulphides is pyrites, both on account of its occurrence and the extent of its deposits. The predominating constituent in this mineral species is bisulphide of iron, with which are frequently associated sulphides of copper and arsenic. . . . When iron pyrites is roasted in the open air an increase of temperature takes place in its mass, so that the oxidation continues without the application of external heat, the sulphur passing off as sulphurous acid gas while the iron is changed into ferric oxide. This process of roasting extends over a considerable space of time, and is so conducted that the heat evoked by the oxidation of the sulphides is never very manifest at any period of the operation. The sulphur and metals frequently burn to fusion, but the utilisation of the heat evolved by this burning has not hitherto been considered a subject of much importance. If, however, a rapid current of air is forced through molten sulphides the maximum temperature of the combustion is attained because all the oxygen of the air is then utilised for oxidation, and the oxidation is concentrated into the space of a few minutes instead of occupying many weeks, or, in the case of cupreous pyrites, several months. When air is forced through liquid sulphides a very energetic action takes place, and the protosulphide becomes converted into protoxide with great rapidity, thus :—

$$FeS + O_3 = FeO + SO_2.$$

In practice fluxes are present during this reaction because the protoxide of iron requires silica to form a slag; and these fluxes can be introduced with the charge of pyrites. Such poor metalliferous substances as the gangue of mines, ancient scoriæ, poor silicious copper ores, etc., containing small quantities of valuable minerals, may thus be advantageously utilised, and the copper, lead, and silver that they contain will be found in the regulus or sublimates. These materials can be introduced in considerable quantities because their specific heat is low."

When it is remembered that in every stage of the Welsh process an external fuel was required, and that about eighteen tons of coal were needed for the production of one ton of copper, it will be appreciated how important was Hollway's insistence on the need for utilising the fuel value of the sulphide ores of copper.

In the last two decades of the nineteenth century, when the United States of America became the largest producer of the metal, very great advances were made in the technique of copper smelting and refining. These have continued during the opening years of the twentieth century, and to-day the position of America is one of unchallenged—though I do not say unchallengeable—supremacy. These advances include the following developments:—

1. Great improvements in mining and ore-dressing operations (mechanical concentration).
2. The use of mechanically-rabbled roaster furnaces.
3. The manufacture of sulphuric acid both from blast furnace and roaster gases.
4. The blast roasting and sintering of sulphide fines.
5. The practical application of the pyritic smelting principle to suitable raw ores, and to practically all copper mattes.
6. An enormous increase in the capacity and output both of blast and reverberatory furnaces.
7. The recovery of metal values from the furnace waste gases.
8. The adoption of electrolytic refining followed in many cases by furnace refining with the recovery of precious metal values in the copper which more than suffice to pay for their extraction.

And, most recently of all,

9. The application of either leaching or flotation processes or both to low-grade ores, tailings, etc.

The effect of all these improvements has been to bring within the scope of practical economic development ores of lower and lower grade, and thus to lengthen the life of existing mines and to include others which, even ten years previously, were incapable of beneficiation. It must not be forgotten, however, that British workers have had an important share in these developments. At most of the great smelters in the new districts in America, now the chief seat of the industry, Welsh furnacemen are still to be found. Large numbers of them went to the United States when the centre of gravity of the industry shifted there. As Mr. Levy points out:* "To meet the enormous present-day demand for metal with the older methods and furnaces would have been impossible. The greatest stimulus to the adoption of these new and modified processes was the shifting of the chief producing centres from the older and more conservative influences to districts like the then newly-awakening west, where, with ever-increasing—almost limitless—supplies of ore available, and free from the necessity of considering the capital invested in old plants, the men in charge of the work, untrammelled by old smelting customs which might stand in the way of rapid progress, were in a position to develop their ideas with originality and vigour."

American supremacy in copper smelting to-day is founded on the possession of immense reserves of ore both in the northern and southern hemispheres of the Continent. So far as the United States proper is concerned, the chief deposits are found in four States—Arizona, Montana, Michigan, and Utah, in descending order of relative importance. The Arizona ores are low-grade porphyries. In Montana, Butte is the chief centre, famous for its veins with rich secondary sulphides. The Michigan ores, to which I have already alluded, are unique deposits of the native metal and in Utah, of which the Bingham district is the most important centre, the ore bodies consist of an altered silicious porphyry containing small grains of copper minerals very uniformly disseminated throughout the mass.

The Tennessee deposits, although yielding, comparatively speaking, a small amount of copper, are important in that they are pyritically smelted, and from the waste gases enormous quantities of sulphuric acid are manufactured. The American copper-mining groups, however, realising how essentially the industry depends for its prosperity on adequate ore resources, have in addition obtained control of rich mines both in Mexico and Chile. Probably no country in the world contains so many copper mines as Chile, and a traveller in that country readily sees why for many years it held the world's supremacy in copper production. The *Mineral Industry* for 1915 states: "A gentleman, well informed with the situation, is authority for the statement that there are probably two thousand mines that are regularly or intermittently worked." The most extensive deposit is that owned by the Chile Exploration Company, whose ore body now

* "Modern Copper Smelting," p. 11.

developed consists of more than 300,000,000 tons with an average of more than 2 per cent. of copper. In Mexico, Sonora produces from 50 to 60 per cent. of the total output, and the largest producer is the Cananea Consolidated Copper Company. The technical practice in copper smelting, which has been developed in America, is directly related to the possession by the operating companies of these immense ore reserves, and, indeed, would be impossible without them. This fact, more than anything else, differentiates American from South Wales practice. The former is based on uniformity of ore composition; the latter was built up on diversity of ore mixtures. Another important difference arises from the immensely greater scale of operations characteristic of American practice, which has caused a veritable revolution in methods of transport and mechanical handling of the materials needed for the various processes which intervene between the raw ore and the refined metal.

I do not think I can illustrate this practice better than by giving you a brief description of the works of the Anaconda Copper Mining Company. It is considerably the largest and, by common consent, one of the most efficient companies in the world. Moreover, its operations illustrate every important process whereby copper is extracted from its ores with two exceptions: (1) Pyritic smelting; and (2) the extraction of the native metal. In every other respect it is a complete epitome of the best technical practice that can be found anywhere. I shall first of all describe Anaconda practice as I found it in the summer of 1914, and then allude to certain important advances which have been made in the last three years, in consequence of which a complete reorganisation of the works has been necessary and has been attended with remarkably successful results.

The company owns about 1,168 acres of mineral claims at Butte, Montana, a great mining centre situated about 5,000 ft. above sea-level. It also owns some 13,000 acres of coal lands, large tracts of lumber land with sawmills and its own water-supply obtained from two lakes. It is operating some twenty-eight mines in the Butte area. The Anaconda mine was originally a silver producer. This gave out at a depth of about 150 ft., where copper ores were found. These were principally chalcocite, bornite, and enargite. As previously mentioned, these occur in veins. One of the mines, the St. Lawrence, has been on fire since 1889 in an extensive area about the 1,100 ft. level. This has been walled in by cement bulkheads where possible, but has never been extinguished. The copper, however, is not lost, for the sintered ore can be mined. Moreover, the mine-waters are charged with copper, which is recovered as "cement" by precipitation with scrap-iron. Mining is carried to a depth of about 3,400 ft. (vertical). The various mines of the company have immense reserves of ore of all grades. The ore mined in 1913 amounted to 4,651,445 tons, the costs being as follows:—

Mining	costs per ton	4·124 dollars
Reduction	,, ,,	1·679 ..
Transportation	,, ,,	0·320 .,
		6·123

The cost is estimated at 10 cents per pound of metal sold, but it is probable that the cost of actual production is not more than 9 cents per pound.

The ores are hauled a distance of twenty-eight miles in trains of fifty 50-ton bottom dump cars to the yards at East Anaconda. Here they are split up according to their destination, which may be either the concentrator and sampling bins or to the storage bins. In either case they are made up into trains of eight or sixteen cars according to the size of locomotive to be used, and are carefully weighed before delivery to their respective bins. The reduction works at Washoe are situated about two miles east of the city. The site includes about 240 acres, and peculiarly adapts itself in topography to the efficient handling of material. It is situated on a hillside, and thus it is possible to make the level of delivery of the product of one building the level of the charge floor of the next succeeding one.

The concentrator bins, which are of wood and steel construction, are divided as follows: Eight second-class storage bins having a capacity of 1,250 tons each; thirteen sample ore bins of 200 tons capacity each, and one coal storage bin of 2,500 tons capacity. The sampling mill is of wood construction, and consists of two complete sections, each having a capacity of 1,800 tons per twenty-four hours. The ore is taken from these bins by an electric locomotive and dropped into bins feeding the crushers. The discharge of these is elevated to the top of the building by means of bucket elevators. The stream of ore is cut four times by Brunton automatic samplers cutting out one-fifth of the amount each time and discarding four-fifths, the final result being 3·2 lb. per ton of ore crushed. The discard is elevated and dumped into concentrator ore bins, or, if it is first-class ore, it is sent to the storage

bins at the blast furnaces. The final sample is quartered, and the resulting sample dried in a steam drier, ground, bucked so as to pass through a 100-mesh sieve, and put up in four separate sample packages. One goes to the laboratory for analysis, another to the owner of the ore, and two are filed away in case of dispute.

What is called first-class ore is material which can be smelted direct, and this goes to the blast furnaces. Second-class ore, on the other hand, requires concentration of its copper values in the mill, and after this treatment goes ultimately to the reverberatory furnaces. The outline of the smelting scheme is as follows:—

Let us in the first instance follow the movements of the first-class or smelting ore, and the coarse concentrates from the second-class ore which are smelted in the blast furnaces. Anaconda was the first smelting works to adopt large furnaces of this type. The building contains three, two of which are 51 ft. and the other 87 ft. long, the width at the tuyeres being 56 in. The capacity of the smaller furnaces is 1,600 tons, and that of the larger furnace 3,000 tons of charge, per twenty-four hours. They were designed by Mr. Mathewson, the superintendent, and are very successful in operation, being much easier to handle than the old style furnaces.

The bottom of the centre of the furnace is of silica brick laid on water-cooled cast-iron plates, mounted on cast-iron columns, and has a gradual slope to each discharge spout. The smaller furnaces have two discharge spouts and settlers, the larger three. Otherwise the construction is similar. The former have eighty-eight 4 in. tuyeres, the latter 150.

The special advantage of these furnaces is that the hearth area has been greatly increased, while there are still only two ends to bind and hold the crusts. Any crusts forming on the sides can be removed by allowing the furnace to run down, the crusts either dropping down or being readily barred. They have a smaller radiating surface for the same hearth area than the furnaces previously used; they use less coke, and constitute a flexible unit, since any part of the furnace can be handled as occasion demands, and can be repaired without shutting down the furnace. This applies also to leaking water jackets, which can be changed in from six to eight hours by the following procedure. The tuyeres on the jacket to be changed and the one opposite are shut off, water is allowed to circulate until all buckstays, tuyere pipes, etc., are removed, and the jacket is ready to be pulled out. This chills a wall inside the jacket, which is strong enough to hold the charge in the furnace. The new jacket is then placed in position, all the connections made, the blast turned on, and smelting resumed. The entire end of one furnace has been shut down, jackets changed, furnace cleaned out, and operations resumed, and during all this time (extending over two weeks) the other half of the furnace was in operation.

The furnaces are charged from both sides, the doors being raised with compressed air. A "charge" train consists of eighteen cars operated by the local tramming system. The cars receive weighed quantities of the various materials from the storage bins adjacent to the building. The ore being very silicious, lime rock is the chief flux used. At the time of my visit, however, a lime iron oxide flux was being tried as well. This was found to go three times as far as the lime rock, and a further advantage was that it contained gold values which, of course, accumulated in the copper. The charge train first takes its quota of flux, then slag (from the converters and refining furnaces), then ore, then coarse concentrates, and, finally, briquettes from the briquetting plant. The briquettes are made of fine ore flue dust and concentrates, pond slum, and fine coke from the ashes of the reverberatory furnace. These materials are ground up in a pug mill and discharged into a brick machine, where they are further mixed and bricks cut out of a bar by a revolving cutter. They weigh about 10 lb., and must be strong enough to keep their form in the furnace until they reach the smelting zone. Two charge cars constitute a charge. The train, when loaded, is hauled into the blast-furnace building, where the cars are dumped by compressed air lifts. The slag and matte flow from the furnace continuously through the discharge spouts into 16 ft. settlers. These are circular and are made of half-inch steel plates lined with 12 in. silica brick. [The company manufactures its own fire and building bricks.] The slag overflows and is granulated by steam water from the concentrator, and is carried off in launders lined with blast-furnace slag plates to the dump. The matte is tapped from the settler into the 10-ton hot metal ladles of the local tramming system, and taken to the converter plant while still molten.

The matte contains from 45 to 50 per cent. of copper, which represents the highest degree of concentration which can be economically made without danger of freezing in the hearth. The slag contains about 0·25 per cent. of copper,

which is thrown away at present. Reference will be made later to the system of treatment of flue dust obtained from this and other furnaces.

THE CONCENTRATOR
(which treats all second-class ore).

This consists of two steel and wood buildings, each containing four complete sections. Seven of these are equipped with the same kind of machinery, and will treat 1,350 tons of ore per section in twenty-four hours. The remaining one can handle 1,600 tons of ore per twenty-four hours. The equipment of the former section is as follows:—

One 12 in. by 24 in. Blake crusher.
Two 15 in. by 5 in. Blake crushers.
Six coarse concentrate Hartz jigs.
One set of 15 in. by 42 in. coarse rolls.
One set of 15 in. by 42 in. fine rolls.
Thirty-six fine jigs.
One set of 15 in. by 42 in. middling rolls.
Twelve middlings jigs.
Three 6 ft. Huntington mills.
Twelve fine finishing jigs.
Thirty-three Wilfley tables.

The latter section is somewhat differently arranged. All sections have a large number of classifiers, settling tanks, dewatering tanks, elevators, and trommels of various sizes. The coarse concentrates, as already mentioned, go to the blast furnaces after being collected in bins at the upper end of the mill. The finer concentrates are carried by a system of launders to settling tanks at the foot of the building. The tank house has nine settling tanks for each section. They are 19 ft. by 19 ft. by 15 ft. high, each having a capacity of 420 tons of concentrates, and are divided up as follows: Four are for first settlement of fine concentrates, two for first settlement of $\frac{3}{8}$-in. concentrates, and three for second settlement of the concentrates. The overflow from the second settlement tanks goes to three large tanks common to all sections in that half of the mill, and finally the overflow from these tanks goes to the dirty water flume, from which it can be pumped for re-use in the mill or used at the smelter. The concentrates caught in the two $\frac{3}{8}$-in. tanks are called $\frac{3}{8}$-in. concentrates, and are treated in the blast furnaces. Those retained in the four fine tanks are called fine concentrates, 80 per cent. of which are treated in the roaster building, and 20 per cent. in the briquette plant. Those caught in the three "second settlement" tanks are called "second settlement concentrates," and are treated in the roaster building. Those finally which are caught in the three large tanks are called "tank house slimes," and are treated at the briquette plant. The tanks containing these various products are emptied from the bottom, after draining, into cars of the local tramming system, and transported to their respective destinations. It is the practice of this plant to weigh and sample the material entering and leaving every building, so that an accurate check is kept on the work of each department.

The mill practice at Anaconda in 1913, good though it was, as judged by comparison with other plants, did not succeed in retaining more than 75 per cent. of the copper values in the ore. [Gravity concentration does not, as a rule, recover much more than 70 per cent.] I allude to this now because a very great improvement in recovery has taken place at Anaconda in the last two years, and I shall have occasion to refer to this in my third lecture. Certainly it was at this stage of the operations that there was the greatest room for improvement.

The slum ponds are situated in the valley below the works, and the water, containing the greater metal values coming from the concentrator, goes to them for settlement. They vary in size, but average from 300 ft. to 630 ft. in diameter. When one pond is full, the water is diverted to another, and the former is drained as much as possible. It is then excavated by one of two travelling cableways, each having a bucket capacity of five tons. The slum is then piled outside and allowed to drain and dry, and from here it is taken by cableway and dropped into a hopper on trucks from which it runs into the railroad cars beneath, and is taken to storage bins for use at the briquette plant.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

Coupling Businesses.—The road ahead of manufacturers working under official contract is moderately clear, but the prospect before all others is cloudy. Official business monopolises all the men, material and machinery that it requires, and it is from no fault of their own that the rest of manufacturers are not employed upon work recognised at the time being as of essential national interest. Their occupations have been regarded as essential enough in times past, and they will come to be so regarded again. Meantime, there is the problem to solve of how to survive with lamentably inadequate supplies of material and an incomplete skeleton force of labour, which is destined to be further reduced. It is uncertain how the feat is to be managed, but there is assurance that the extreme desirability of keeping nucleus industries together is admitted in the most authoritative quarters.

The individual would, of course, prefer to maintain intact a remnant of his individual business with freedom to ensure it in his own way. Natural predilection is all in favour of that course, but considerations of economy are said to dictate another. Manufacturers carrying on business in reduced circumstances may be urged to combine operations with a view to economies in staffs and in fuel. Proposals to close given premises and transfer their work to other mills are safe to meet some resistance. There are as many differences in points of practice between neighbouring mills as between neighbouring households, and the differences are not much easier to assimilate. Decidedly, some permanent results must be looked for from the policy of temporary syndication, should it be carried into effect.

Devolution.—It is with syndication as with other of the expedients for regulating trade during the war. Each departure from traditional custom awakens suspicion that the proposal contains more than meets the eye, and is actuated by plotters with ulterior ends to serve. Employers, no less than trade unionists, look for the restoration of the privileges that they have patriotically foregone, but there is the difference that employers have not hitherto been given the same explicit pledge. The air has been cleared, however, by the emphatic declarations given in respect of the Imports and Exports (Temporary Control) Bill. The outspoken assurances to deputations of textile traders have considerably weakened the fear that the noose of State control would be tightened and permanently fixed about their necks. The Government can have no illusions as to the real feeling of traders about the control to which they passively submit, and, given a good disposition upon its part, there will certainly be no delays in remodelling affairs upon a free basis.

State Management.—The progressive encirclement by State control is by far the most notable development of the past year. The pincers have closed around the woollen industry until the points have met. Military demand for flax has so grown that after mid-January none can be put into work without a permit. The small surplus of jute left behind after satisfying official orders is so far from free that it cannot be exported except under express permission, and such of it as is made into Hessian canvas for the normal civil market has to be sold at a controlled, although not ungenerous, price. Cotton is under the more enviable control of a Board wholly elected by the trade, and silk has the advantage or disadvantage of being uncontrolled except as all trades are controlled in regard of their general liberty. The balance of advantage under existing circumstances is difficult to strike, and in one way and another it is made pretty certain that for the rest of the war the textile industries cannot be operated for personal profit.

Direct Trading.—The decision taken by one of the most considerable Huddersfield manufacturing firms to offer its goods henceforth by direct sale to tailors is a sign of the times. The manufacturer, as he becomes more wealthy, tends to become less patient of the wholesale merchant, and the dissatisfaction of the manufacturers of fine woollen and worsted cloths has been visibly increasing for years. The example will not improbably be followed by others similarly placed, and under given conditions, the change should not be uneconomical. Beyond any part that he plays as the financier of operations, the merchant serves to bring a wide variety of goods into relatively a small compass. Not many manufacturers produce a range of goods wide enough to make their direct supply economical, and hence it so often comes that the direct-trading manufacturer turns merchant by buying from others and reselling more goods than he makes for himself. To a limited extent the merchant of sufficient capital and connection tends to become manufacturer, buying material raw and getting it manufactured upon commission. One has as good a right to extend his functions as the other, and although it might seem that these processes threaten extinction to the simple merchant, they have not hitherto worked on a sufficient scale. The merchant has easily survived, and—short always of the forming of complete combinations of manufacturing firms—it is probable that his services will always find a place.

Textile Schools.—The war has been unkind in some respects to technical education, and notably in reducing the supply of competent instructors. Lack of teachers is a greater trouble in some institutions than lack of students, for despite Army claims a large number of young men of incomplete education have been left to perform indispensable industrial work. In a degree the war has even stimulated the demand for textile instruction, for promotion in the lower ranks of industry has been unwontedly rapid; and men, thrust into posts for which they are only partly equipped, have turned to the evening schools to amplify their knowledge. It may also be that men exempted on the score of their occupation have felt it incumbent upon them to make themselves as proficient as possible at their allotted tasks. The classes for day students ordinarily attended by youths of 18 to 19 years are barer than usual, and in several centres have never been well filled by those for whom they are intended. Conceivably the end of the war will send new flocks to the day classes, by which time the needs of these students should be more fully supplied.

GENERAL NOTE.

Oil in the United States.—The principal oil-producing states in America are California, Oklahoma, Illinois, West Virginia, Texas, Louisiana, Ohio, and Pennsylvania. Over 33,500,000 barrels of fuel oil, according to the *Engineer*, are annually consumed by railways. The total yearly oil-

production of the United States is about 222,500,000 barrels of 42 gallons, and is furnished by the six great fields and a few scattered states. The greater part of the oil produced from the Gulf and Californian fields is consumed as fuel.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m. :—

January 16. — Reginald S. Clay, D.Sc., Principal of the Northern Polytechnic Institute, "The British Pianoforte Industry." Sir Frederick Bridge, C.V.O., Mus.Doc., will preside.

January 23. — Alexander Newlands, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in Great Britain (with special reference to Scotland) : its Amount and Economic Value." Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

January 30.—Sir William George Watson, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." Sir Arthur D. Steel-Maitland, Bt., M.P., will preside.

February 6.—Wm. Frecheville, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of Mineral Resources of the Empire." Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

February 13.—Lord Leverhulme, "The Relations between Capital and Labour — Reasonable Hours, Co-partnership, and Efficiency." W. A. Appleton, C.B.E., Secretary of the General Federation of Trade Unions, will preside.

February 20.—Maurice B. Adams, F.R.I.B.A., "Picturesque Architecture." Sir Aston Webb, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

February 27.—Sir William H. Clark, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The Right Hon. Lord Faringdon will preside.

March 6. — A. H. Paterson, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The Right Hon. Frederick Huth Jackson will preside.

March 20. — Frank Stuart Courtney, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." Sir John Snell, M.Inst.C.E., will preside.

Dates to be hereafter announced :—

Major Sir Robert Armstrong Jones, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War."

Martin O. Forster, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

George Martineau, C.B., "Sugar from several Points of View."

John B. Farmer, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. Lawrence Ball, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

Indian Section.

Thursday afternoons, at 4.30 p.m. :—

January 17.—H. M. Surtees Tuckwell, M.I.Mech.E., "The Tata Iron and Steel Works." The Right Hon. Lord Sydenham, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., will preside.

February 14. — Sir Henry Ledgard, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India."

March 14.—

April 18.—Alfred Dickinson, M.Inst.C.E., "Water Power in India."

May 30.—Hon. Sir Dinshaw E. Wacha, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Colonial Section.

Tuesday afternoons, at 4.30 p.m. :—

February 5.—C. du Plessis Chiappini, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

March 5.—

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

Cantor Lectures.

Monday afternoons, at 4.30 p.m. (unless otherwise announced) :—

Charles R. Darling, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical

College, Finsbury, "High Temperature Processes and Products." Three Lectures.

Syllabus.

LECTURE I.—JANUARY 21.—*Methods of Producing High Temperatures.* Special fuel furnaces—Oxy-hydrogen flame—Oxy-acetylene—Thermit—Electric furnaces.

LECTURE II.—JANUARY 28.—*High Temperature Processes.* Smelting of platinum and metals of high melting-points—Welding and cutting by oxy-acetylene flame and electric arc—Thermit welding—Production of steel and other metals by electric furnaces—Fixation of atmospheric nitrogen—Metal spraying.

LECTURE III.—FEBRUARY 4.—*Products and their Uses.* Artificial graphite for various purposes—Carborundum for abrasion and refractory purposes—Alundum and silica for chemical apparatus and refractories—Calcium carbide for making acetylene—Pure metals by thermit processes—Siloxicon and other silicon—Carbon compounds for refractories and thermal insulators—Aloxite and its uses.

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Economic Condition of the United Kingdom before the War: The Real Cost of the War: and Economic Reconstruction." Three Lectures.

February 18, 25, March 4.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JANUARY 14... Faraday Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5.30 p.m. General Discussion on "The Setting of Cements and Plasters." 1. Dr. C. H. Desch, "The Mechanism of the Setting Process in Plaster and Cement." 2. Professor H. Le Chatelier, "Crystalloids *v.* Colloids in the Theory of Cements." 3. Mr. A. A. Klein, "The Constitution and Hydration of Portland Cement." 4. Mr. G. A. Rankin, "The Setting and Hardening of Portland Cement." 5. Mr. B. Blount, "The Setting of Cement in its Relation to Engineering Structures." 6. Mr. J. Rhodin, "Note on the Colloidal Theory of Setting." 7. Mr. E. H. Lewis and M. E. Deny, "The Effect of the Addition of Suitable Slag on the Setting Properties of Portland Cement." 8. Mr. W. J. Dibdin, "Ancient and Modern Mortars."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Rev. Canon J. O. Hannay, "The Church and the Army."

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m.

TUESDAY, JANUARY 15...Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Mr. L. Gaster, "Ten Years of Illuminating Engineering: its Lessons and Future Prospects."

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Captain T. S. Masterson, "The Petroleum Industry of Rumania."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor W. M. Flinders Petrie, "Palestine and Mesopotamia: Discovery, Past and Future." (Lecture I.)

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 6.30 p.m. Mr. J. Beaumont, "Ravenna: its Architecture and Mosaics."

WEDNESDAY, JANUARY 16...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. R. S. Clay, "The British Pianoforte Industry."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Biblical Archaeology, Society of, 37, Great Russell-street, W.C., 4.30 p.m. Mr. S. Langdon, "Three Hymns in the Cult of Deified Kings of Ur and Isin."

Microscopical Society, 20, Hanover-square, W., 8 p.m. Presidential Address by Mr. E. Heron-Allen, "The Royal Microscopical Society during the Great War—and after."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Lecture by Professor W. de la Mare.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Dr. C. K. Millard, "The Problem of Birth Control, with special reference to the Public Health Aspect."

THURSDAY, JANUARY 17... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. H. M. S. Tuckwell, "The Tata Iron and Steel Works."

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. E. S. Goodrich, (*a*) "Restoration of the head of *Osteolepis*"; (*b*) "Femur of Pterodactyl from the Stonesfield Slate." 2. Mr. J. Britten, "Some early Cape Botanists." 3. Mr. C. E. Salmon, "A hybrid *Stachys*."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W., 7.30 p.m.

Chemical Society, Burlington House, W., 8 p.m.

University of London, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture I.)

Royal Institution, Albemarle-street, W., 3 p.m. Professor S. Wilkinson, "Generalship—a Battle of Napoleon (Austerlitz)." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.30 p.m.

FRIDAY, JANUARY 18...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor Sir James Dewar, "Studies in Liquid Films."

Mechanical Engineers, Institution of, Storey's-gate, Westminster, S.W., 6 p.m.

SATURDAY, JANUARY 19... Royal Institution, Albemarle-street, W., 3 p.m. Professor W. J. Pope, "The Chemical Actions of Light." (Lecture I.)

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, JANUARY 18, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 21st, at 4.30 p.m. (Cantor Lecture.) CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." (Lecture I.)

Fellows are requested to note that the hour of these lectures has been changed to **4.30** p.m. instead of 8 p.m., as at first announced.

WEDNESDAY, JANUARY 23rd, at 4.30 p.m. (Ordinary Meeting.) ALEXANDER NEWLANDS, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in Great Britain (with special reference to Scotland): its Amount and Economic Value." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

INDIAN SECTION.

Thursday afternoon, January 17th; the RIGHT HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., in the chair. A paper on "The Tata Iron and Steel Works" was read by Mr. H. M. Surtees Tuckwell, M.I.Mech. E.

The paper and discussion will be published in a subsequent number of the *Journal.*

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and can be obtained by Fellows on application to the Secretary.

EXAMINATIONS.

Application forms for the March and May Examinations will be sent to all centres at the end of this month. The last day for receiving applications for papers for the March Examinations is Monday, February 18th.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

PROGRESS IN THE METALLURGY OF COPPER.

By H. C. H. CARPENTER, M.A., Ph.D., M.Inst.M.M., A.R.S.M.,

Professor of Metallurgy, Imperial College of Science and Technology.

Lecture III.—Delivered December 17th, 1917.

ROASTER PLANT.

The fine and second settlement concentrates then pass to the roaster building. This is of steel construction throughout, and contains sixty-four calcining furnaces of the Evans-Klepekto type. They have six hearths 16 ft. in diameter, and are 18 ft. high, and they have revolving water-cooled shafts and arms, driven by suitable gearing from the bottom. The rabbles are so set as to move the material from the circumference to the centre, and *vice versâ*, on alternate hearths, until it finally drops into the calcine hoppers immediately over the tracks of the local tramming system for transportation to the charge floor of the reverberatory building. No fuel is used other than the sulphur in the concentrates, the burning of which furnishes sufficient heat to do the calcining, except on occasions when the furnace is not hot enough to ignite the sulphur, at which times fine coal is fed in. The gases are led through brick flues into large brick and steel dust chambers, where a large proportion of the flue dust is settled. These chambers are constructed so that the bottom is a series of hoppers which permit of the delivery of the dust into cars which transport it to the reverberatory furnaces. The material which sticks to the rabble arms, centre shaft, etc., called "barrings," is barred off and sent to the blast furnaces. The wet dressing of the second-class Butte ores

produces a concentrate containing about 9 or 10 per cent. of copper from an ore containing originally about 4 per cent. Direct smelting of the original ore in a blast furnace would not yield a matte of "converter" grade, except at very heavy expense and difficulty.

The fine material obtained after water concentration cannot be conveniently treated in a blast furnace, and is smelted in a reverberatory furnace. Since the atmosphere of this type of furnace is to a great extent neutral, the charge would tend simply to melt down without much reduction of sulphur, and a low-grade matte would thus result. This is why roasting is necessary, since the roasting furnace can be operated so as to reduce the sulphur to the desired extent, and thus produce a charge which on melting in the reverberatory will give a matte of converter grade. In all modern practice the work of the reverberatory plant is controlled at the roasters. At Anaconda the sulphur is reduced from 30 to about 8 per cent., and the output of the plant is about 3,000 tons of calcines per twenty-four hours. The entire charge for the reverberatories, viz., concentrates, flue dust, and lime-rock, is passed through the roasters. This promotes the necessary mixing of the charge and has improved the yield of matte per ton of coal. At the time of my visit the reverberatory furnace plant was just about to undergo important alterations. There are two steel buildings, each containing four furnaces fired by coal burnt on a separate grate. The hearth dimensions are from 102 to 116 ft. in length by 19 ft. in width, the grate area being 16 by 7 ft., and the smelting capacity about 260 tons per twenty-four hours on natural draught. A coal-dust fired furnace, however, had been built and trials were about to take place. I shall allude to this presently.

The flame, after leaving the furnace, passes through two 375 h.p. Stirling boilers in tandem, which reduce the temperature of the gases going to the main flue to about 315° C., and by means of this 600 b.h.p. are obtained from each furnace. Mr. Demond, the company's experimental engineer, informed me that he considered that not more than 19 per cent of the heat generated by the combustion of the coal was utilised in smelting, and about 32·8 per cent. in steam-raising, the balance, viz., about 48 per cent., being lost. The velocity of the gases, according to his measurements, was about 20 ft. per second. Less than one-fifth of the total heat was therefore utilised in the right place, *i.e.* on the hearth.

The ashes and partly-burned coal which drop from the firebox fall into a stream of water which carries them over a grizzly, the larger pieces of ash going to the ash-sluice, the smaller —containing coke and unburnt coal—being sluiced to the coke-jigging plant. The coal and coke thus recovered are finally taken to the briquette plant and become a constituent part of the briquettes. Ten per cent. of the reverberatory fuel is thus recovered and utilised in the blast furnace.

Slag is skimmed from the furnaces twice in eight hours. It is allowed to accumulate until its depth is from 3 to 4 in. above the skimming plate in front of the furnace, and there it is skimmed from the end into the stream of slum water which granulates and sluices it through a launder to the slag dump. In this way about 60 tons can be removed in twenty minutes. The matte is kept down some distance below the skimming plate, making it impossible to "pull" any of it out, thus avoiding loss of copper and explosions. It is tapped from the side of the furnace and run through cast-iron launders lined with silicious material to hot-metal ladles of 10 tons capacity, and is taken by the local tramway to the converters.

The matte is of rather lower grade than that produced in the blast furnaces, and varies from 40 to 45 per cent. copper; but it is still of converter grade and can be treated without more ado. The slag carries up to about 0·3 per cent. of copper, which is thrown away.

In the next stage, the matte, whether produced in the blast or the reverberatory furnace, is Bessemerised up to blister copper. In other words, the fuel value of the sulphur is utilised to create and maintain the heat necessary for oxidising the iron, slagging it off by additions of silica, and for removing sulphur from the white metal and blowing it up to blister metal. Until recently the converters used have been of the horizontal "barrel" type, 8 ft. in diameter and 12 ft. 6 in. in length, which are operated hydraulically. They are lined with magnesite and have a capacity of about 15 tons of matte. The company, however, has developed at their Great Falls plant a new converter of much greater size, and this has now replaced the above-mentioned plant. The Great Falls converter is of the upright type and has a capacity of about 80 tons of matte, the diameter being 20 ft. The particular advantage attaching to it is that overheating, which was always a danger with the smaller furnaces, is seldom, if ever, liable to occur.

The matte is brought to the charge floor of the converter building, which is 23 ft. above the operating floor. It is poured from the ladle into a launder, the end section of which is pivoted so that it can be turned out of the way when the converter is filled. The practice is to blow the matte first of all with no flux, in order to produce magnetic oxide of iron. This deposits on the magnesite lining and constitutes a valuable protection against the corroding action of the slag. After it has formed, the necessary flux is added and blowing continued. There are two main stages: (1) the elimination of iron sulphide; (2) the removal of the remaining sulphur. The product of the first stage is a white metal, almost pure cuprous sulphide, the iron of the matte having been slagged off as ferrous silicate, and the corresponding sulphur eliminated as SO_2. The oxidation of the iron produces the greater part of the heat evolved. The flame during this period is green in colour, due apparently to the formation of ferrous silicate. When this stage is completed and the slag has been poured off—as already mentioned, this goes back for treatment in the blast furnace—the white metal is blown up to blister copper, this constituting the second main stage of the process. Much less heat is evolved in this stage, and the colour of the flame varies from red-purple to bronze-purple. It is tolerably non-luminous. The progress of the blow from matte to white metal, and thence to blister copper, is usually indicated and controlled by the appearance of the flame during the first periods, and the character of the emitted shots of metal in the later stages. It takes from seven to eight hours to blow the 80-ton charge. When ready, the latter is poured into steel ladles lined with converter slag and taken to the refining and casting furnace, where it undergoes a preliminary refining and is cast into a form suitable for subsequent electrolytic refining. Converter metal contains about 98·3 per cent. of copper. For modern electro-refining practice the crude metal must be cast into anodes, which are usually in the form of plates about 2 ft. 6 in. by 3 ft. by 2 in. thick. It is found that the metal as produced in the converters, on being cast into such plates, does not, as a rule, yield anodes which work satisfactorily in the tanks. This is largely owing to the impure and crude condition of the metal, which results in the production of plates which are spongy, coarse, and exceedingly rough and uneven on the surface. The direct employment of such metal would occasion irregularity and difficulties in the operation of the tanks, giving rise to short circuits, uneven wear, breaking off in large pieces, and similar troubles. Furthermore, the tank liquors and slimes become badly contaminated if large quantities of impurities be present in the anodes, and the deposition of good, clean metal is greatly interfered with. All these reasons render it advisable that the converter copper should, as a rule, undergo a preliminary furnace refining before being cast into anodes.

Anaconda practice is representative of the manner in which these operations are conducted, except that the enormous scale and organisation of the work are practically unique. The principles involved, however, and the general method of operation are in all essentials those of the old Welsh furnace-refining process.

There are three casting furnaces, one having a capacity of 110 tons and two of 140 tons. Two of these are in operation all the time. Owing to the high conductivity of copper, and to the fact that the functions of the furnace are either largely as a medium for simple fusion or as a receptacle for molten metal, that but little slag is produced, that no settling and separation of the fluid materials are required, and that there is no danger of dusting losses, the furnaces are built with deep hearths. These have to be very strongly constructed, and are of silica brick. The copper is poured in at the side, and as soon as the furnace contains 50 or 60 tons, oxidation by air conducted through pipes at 15 lb. pressure is commenced. When the furnace is full the slag is removed and oxidation completed; the charge is then poled back to the desired pitch and cast. The casting machine is a platform conveyor with the moulds attached and operated hydraulically. The molten copper is run into a suspended ladle, from which it is poured, also hydraulically, into the mould on the machine. When a mould is full the ladle is dropped to a horizontal position, and the conveyor is moved so as to bring the next mould into position, and the process is repeated. Twenty-five tons of copper per hour can be cast in this way.

The copper is chilled by a spray and, when "set," is dumped from the mould on to a platform conveyor, operating through a tank of water, taken to cars, weighed, and sent by rail to the refinery at Raritan, near New York harbour. A train leaves the works daily with a freight of 300 tons of these anodes on its two-thousand-mile journey eastwards.

The metal which reaches the Raritan refineries from Anaconda averages from 99·3 to

99·8 per cent. of copper. It contains also about 80 oz. of silver and 0·5 of an ounce of gold per ton. The method of arranging the electrodes in the depositing tanks is that known as the parallel or multiple system, in which all the anodes in one tank are connected to one pole of the circuit and the cathodes situated between them to the other. Each tank has thirty anodes and thirty cathodes, and there are three thousand tanks in all. In this way each tank constitutes one large anode and one large cathode, and the voltage, as measured between any two neighbouring electrodes, is the same. The system thus allows of the use of currents at low voltage and the danger of short circuiting is lessened. The tanks themselves are arranged in series. They are distributed on a series of descending levels, and the liquor flows from one set to the next by gravity through lead pipes, and is kept in circulation by pumps. The cathodes consist of thin plates of pure copper corresponding in size to the anodes. The current density is about 12 amperes per square foot, the voltage 0·2, and the temperature of the electrolyte 55° C. One anode stays in as long as three cathodes. The latter are allowed to grow until their thickness is $\frac{35}{100}$ in. They are then removed, otherwise nodulising occurs, and this sets up short circuits. The anodes last about one month, and are then taken back to the anode-casting furnace. From the sludge in the tanks are obtained gold, silver, platinum, palladium, selenium, and tellurium.

The electro-deposited copper, whose purity is from 99·95 to 99·98, still requires one more treatment. The metal, in spite of its high degree of purity, is not tough, nor is it in a shape suitable for industrial use. It is, therefore, given a final furnace-refining of the same character as that which preceded the electrolytic refining, and is cast into ingots. The refining furnace has a capacity of about 220 tons, and can be charged in two hours. From this the copper can be cast at the rate of about one ton per minute. Sometimes phosphorus is added as phosphor copper in order to ensure soundness. When intended for conductivity work the metal is cast into wire-bars of varied shape and size according to requirements. Some of these are 500 lb. in weight, and measure 7 ft. by 4½ in. square. Before casting, samples of copper are taken and drawn down into wire and tested for electrical and mechanical properties. The effect of this final operation is to reduce the purity of the copper, owing to the introduction of oxygen, to about 99·7 to 99·8 per cent.

Thus we see that the manufacture of high-grade commercial copper by the above processes requires, in the case of first-class, or smelting ore, five operations, and in the case of second-class, or concentrating ore, seven operations. The plant involved and the concentrations effected in the treatment of the second-class ore are as follows:—

Stage.	Plant.	Product.	Concentration of Copper.
		Ore	About 4 per cent.
1	Mill	Concentrates	From 9 to 10 per cent.
2	Roaster	Roasted Concentrates	
3	Reverberatory Furnace	Matte	From 40 to 45 per cent.
4	Converter	Liquid	„ 98·0 to 98·3 per cent.
5	Refining Furnace	Anode Copper	„ 99·3 to 99·8 „
6	Electrolytic Refinery	Cathode Copper	„ 99·95 to 99·98 „
7	Refining Furnace	Merchant Copper	About 99·7 to 99·8 „

[In the case of first-class ore the blast furnace takes the place of the first three stages in the above table, and concentrates direct to about 45 per cent.]

A few words are now necessary as to the treatment of the volatile products of the smelter. So far as the oxides of sulphur are concerned a small proportion of the total production is converted into sulphuric acid, which is used, *e.g.* in the leaching plant to which I shall refer presently. Almost the whole of these oxides are, however, wasted. Every twenty-four hours about 2,000 tons of sulphur oxides are discharged from the stack at the top of the plant into the atmosphere, an amount equal to almost seven times the weight of copper produced in the same time.

Connecting the various furnaces with this stack there is, however, an elaborate flue system, which is remarkable on account of its immense size. The three principal flues—viz., the blast, the roaster, and the reverberatory—are 20 ft. wide and 15 ft. high, and are of brick and steel construction. The converter flue consists of two 7 ft. by 7 ft. flues. The blast, roaster, and converter flues connect with their respective dust chambers, while the reverberatory flue connects direct with the furnaces. The lengths of the flues are as follows: Blast, 1,653 ft.; roaster, 483 ft.; converter, 703 ft.,; reverberatory, 1,253 ft.

These flues all merge into one main flue, of which the plan and cross-sections are shown on the screen. For the first 1,234 ft. this flue is 60 ft. wide, the side-walls are 20 ft. high, and the bottom is excavated at an angle of 30° from the horizontal. The remaining distance to the stack is 995 ft. of 120 ft. flue. The stack is 300 ft. high with an inside diameter of 30 ft. The top of this stack is 932 ft. above valley level.

The flue dust is drawn off through hoppers, spaced every 10 ft. in the tunnel, into cars operated by the gravity system from a set of drums placed immediately behind the stack. When the cars are loaded they are sent to the lower end of the main flue and elevated to the adjacent flue-dust bins. There are two sets of bins here—one for dust containing the desired percentage of arsenic for the arsenic plant, the other for dust which goes direct to the reverberatories. The arsenical flue dust is worked up in two stages to a product containing 99·8 per cent. of arsenic trioxide, and the residues go to the reverberatories.

I now come to certain important changes which were made in the works in 1914–1915, as a result of which the plant has been remodelled to a great extent and very remarkable improvements effected. Flotation and leaching plants on a large scale have been installed, a new roaster building has been erected, the entire reverberatory furnace plant has been rebuilt and a new method of firing adopted, and, most recently of all, the Cottrell process for agglomerating and collecting fine particles contained in gases moving at high velocity has been adopted for the recovery of mineral values from the flue dust passing out of the new roasters. The total cost of these alterations was more than six million dollars, and, according to Weed's Handbook (1916), this was entirely defrayed in the first six months of operation of the new plant. If this is the case the results must be regarded as a remarkable triumph for the judgment and foresight of the management and the skill of the company's staff.

The most striking of the improvements effected has been by the application of flotation processes to the slimes and tailings produced in the mill. In these processes, as you are no doubt aware, the sulphide particles are made to float on a froth produced by the agitation of the pulp with the addition of a small amount of oil and acid, while the gangue, although specifically lighter, sinks. Surface tension and not gravity is the principle utilised in the separation. As Mr. Ingalls has aptly expressed it, flotation is "concentration upside down." Although the commercial application of this principle has been accomplished only within the last few years, mill operators have always been puzzled, and indeed annoyed, by the action of minerals and metals under certain conditions. The amalgamator has always been bothered by his fine gold, or greasy gold, or tabular gold, which persisted in floating away from his amalgamated plates in spite of all his efforts to gather it. Operators of concentration mills have always noticed the escape of finely-ground sulphides on the surface of the water, and they have never been able to overcome that flotation tendency. In the concentration of molybdenite ore the floating tendency of that mineral has sometimes made ordinary gravity concentration impossible. Even the cyanide plant operator has often encountered a high-grade floating scum that he could never entirely abolish. Flotation is merely the recognition of the existence of these tendencies and the utilisation of them in securing better results than could be obtained by gravity concentration. Flotation concentration is "the taking advantage of the principles of surface tension and colloid chemistry, with whatever allied principles may be involved, to separate mineral from gangue by means of floating it upon the surface of water or other solutions while the gangue is induced to sink through the surface and settle separately." *

The procedure adopted at Anaconda has been described by Laist and Wiggin in the *Bulletin* of the American Institute of Mining Engineers, March 1916. Early in 1914 it was decided to test, on a large scale, the treatment by flotation of the slime and mill-tailing. For this purpose a standard-type minerals separation machine was installed at the works in May and June. This was followed by the installation of a full-

* H. A. Megraw, "The Flotation Process," 1916, p. 3.

size Callow pneumatic plant. Tests were also made with a minerals separation machine of the sub-æration type.

During the series of experiments a large variety of oils was tested. Experiments were also made using both round-table feed and tailing to determine whether it would be better to displace the round tables by flotation for the treatment of the slime, or to supplement them by flotation of the tailing. A series of tests was also made on the treatment of the mill-tailing by grinding followed by flotation to determine the relative merits of flotation and leaching for this product. In addition, flotation tests were made on mixtures of mill-tailing and slime. The round-table feed referred to is the total slime from the mill. It contains about 35 per cent. of colloidal solids and approximately 90 to 95 per cent. of the total solids will pass through 200 mesh (0·067 mm.). It assays from 2·3 to 2·6 per cent. of copper. The mill-tailing is the total discard from the mill exclusive of the slime. It is all finer than 2 mm., and from 90 to 95 per cent. will remain at 0·25 mm. It assays about 0·60 per cent. of copper.

The result of a large number of tests has caused the adoption of the following procedure:—

1. The round tables have been abolished.
2. All slime is treated by the flotation process.
3. The mill-tailings are treated by a leaching process.

As regards flotation the procedure is as follows:—

1. *The Concentration Flotation Division.*—Each section of the mill has the necessary Hardinge or tube mills for fine grinding (below the classifiers), followed by Dorr classifiers in closed circuit with these mills. Following this come four minerals separation flotation machines, having fifteen agitators and fourteen spitzkasten each, and individual 150 h.p. motors. The speed of the agitators is 225 revolutions per minute, and as the impellers are 18 in. in diameter the peripheral speed is about 1,060 ft. per minute. Each machine makes three products—a concentrate which goes to the dewatering division, a middling which is returned to the head of the machine, and a tailing which goes to waste. The concentrate is taken from the first three to five spitzkasten, and the middling from the last nine to eleven. About 6 to 8 lb. of 50° Be' H_2SO_4 per ton of flotation feed are used, together with 2 to 3 lb. of kerosene sludge acid and ½ to 1 lb. of crude wood creosote. The pulp is heated to from 60° to 70° F. by passing live steam in at the head of the machine. Each machine has a capacity of about 400 tons per day on sand and 175 tons on slime. The tailing averages about 0·25 per cent. of copper. The flotation concentrate from this is sent to Dorr thickeners, and there thickened to about 60 per cent. solids for delivery to the Oliver filters.

On account of lack of space in the mill an auxiliary plant had to be installed to handle the extra slime. This plant, known as the slime concentration department, embraces three divisions: (1) The slime thickener division; (2) the slime flotation plant, and (3) the slime concentrate thickener division. In the first named there are 160 Dorr thickeners, each 28 ft. in diameter by 3 ft. deep, arranged in batteries four tanks high. Each battery is served by a central shaft carrying eight rake arms, two to each tank, but each tank is a complete unit. This department thickens all slime made in the concentrator above the fine-grinding mills from about 3 per cent. solids to about 15 per cent. solids. Two-thirds of the thickened product goes to the slime flotation plant and one-third is returned to the concentrator flotation division, the fourth machine in each section being reserved for this purpose. The overflow from these tanks is practically clear water.

The slime flotation plant contains twenty minerals separation machines of the same size and design as those in the concentrator flotation division. Original mill slime thickened to 15 per cent. solids is fed to fourteen machines, and returned dry slime from the slime ponds is fed to six machines. The latter is first pulped in two pug mills, then through two Hardinge mills using silex linings and pebbles, and is elevated to the six machines treating this material. The table on page 147 gives the analyses of the current slime, the concentrate, and the tailing obtained in the experimental slime plant, and Messrs. Laist and Wiggin say in their paper that those are typical of the results that may be expected in the large plant.

From the flotation plant the product is elevated to the slime concentrate thickener division. This building contains five tanks, each of which is 50 ft. in diameter and 12 ft. in depth. The feed contains about 15 per cent. of solids, the spigot product about 60 per cent. of solids, and the overflow is sent to the slime ponds for further settling. It should be mentioned, however, that considerable difficulty has been and still is experienced with flotation concentrate in these tanks, owing to the extremely

Per cent.	Feed.	Tailing.	Concentrate.
Cu	2·10	0·27	12·0
SiO_2	61·00	67·70	20·0
FeO	4·10	2·70	28·0
S	4·40	1·10	
Al_2O_3	19·00	18·30	
CaO	0·60	0·70	
Ag*	1·80	0·20	
Au*	0·005	0·001	

* Ounce per ton.

persistent portion of some of the froth which cannot be made to settle, and is thus lost. To obviate this as far as possible, a circular baffle near the overflow and a large square one towards the centre of the tank have been installed, and have minimised these losses. Also, in order to break up the froth in the concentrate a saucer-shaped disc 3 ft. in diameter was constructed. This was revolved at a speed of 300 revolutions per minute inside a circular tank. The concentrate pulp was fed on to the disc at the centre, and was thrown out against the sides of the tank. The impact broke up the froth to a great extent. The difficulties experienced should cause no surprise, since they arise from the excessively fine condition of the flotation concentrate. More than half of this, Mr. Demond informs me in a recent letter, will pass through a sieve with 300 meshes per linear inch (0·044 mm. opening). In spite of losses due to this cause the total recoveries in the concentrator have, by the adoption of flotation methods, been raised from 76 to no less than about 95 per cent. This is a most remarkable achievement, and reflects the highest credit, not merely on the Anaconda Company's technical staff, but on the performance of the machines of the Minerals Separation Company.

The feed to the Oliver filters is the spigot product from all flotation concentrate thickeners. There are eleven continuous filters, each having a capacity of about 150 tons per twenty-four hours when delivering a product containing 15 per cent. of moisture. They are operated under a vacuum of about 16 in. of mercury furnished by Roots' exhausters. The product, filter cake, is delivered to one of the roaster buildings on the briquette plant. The new roaster building, No. 2, contains twenty-eight roasting furnaces of the Anaconda type — a modified wedge MacDougall furnace. They have seven hearths (one being an open hearth on top for mixing and drying the charge) 25 ft. in diameter. They have five-foot brick-lined revolving hollow shafts, carrying four arms for the two top hearths, and three water-cooled arms for the remaining hearths. The special feature of this roaster is that it contains ports between the two doors. These are intended to allow part of the air to by-pass the drop-hole, located along the outside of the hearth in order to lessen dusting. The ledge projecting from the side of the calcine rabble arm holds a permanent layer of dust in the arm, which serves to protect it from excessive heat. It has been found that a step-bearing carries the load much more satisfactorily than the roller-bearing which was used at first. The calcine is drawn into local tramway cars, and is taken to the reverberatory furnaces.

Above the roaster are now installed four Cottrell units in a structure located over the main 25 ft. by 25 ft. flue. These are designed to recover metal values in the dust carried by the gas stream. The principle of the Cottrell process, which is simply an adaptation to large-scale practice of the original discoveries of Sir Oliver Lodge, is the coalescence of the fine-dust particles under the influence of a high-tension direct current, so that they become large enough to deposit under the influence of gravity. The units employed are of the so-called "box" type. Each contains twenty-one plates 20 ft. high and 24 ft. long, 11¾ in. apart. Each plate is made up of sheets of 20-in. corrugated iron, the axes of the corrugations being horizontal. Corrugated sheets are used in preference to flats on account of their stiffness. Between the plates are hung steel chains ½ in. thick over all. The gas flows upward from the bottom, and returns to the flue by way of a common down-take, the distribution of the flow being controlled by butterfly dampers on the top of the unit. The voltage between the electrodes is about 50,000, and the total power consumed between 90 and 100 horse. Somewhere about 800,000 cubic feet of gas per minute, at a temperature of 200° C., pass through the four units, though they were designed for only half this quantity. The dust recovered is about 70 tons per twenty-four hours from the treatment of 1,500 tons of concentrate, the greater portion of which comes from the Oliver filters. It contains per ton approximately the same metal values as the calcine. A new plant is soon to be installed, which will follow the present units

somewhat closely in design. Probably, however, the walls will be of brick in order to reduce the chilling of the gases, which has a markedly disadvantageous effect on the distribution of the gas flow.

The reconstruction of the reverberatory furnace plant has brought about a striking improvement in the rate of production of matte. Mr. Demond informs me that whereas they formerly smelted from 230 to 270 tons of charge per twenty-four hours with a consumption of 60 tons of coal, they now smelt from 530 to 580 tons in the same time with 95 tons of coal. The output of each furnace has therefore been more than doubled, and the fuel ratio has gone up from about 4·2 : 1 to almost 6 : 1. Indeed, better figures than these have been obtained, for Mr. Bender,* in his paper on this subject, states that with an average daily tonnage of 542·7, the fuel ratio was 7·5 : 1. The last figure brings the reverberatory furnace almost to a level with the blast furnace from the standpoint of fuel consumption. These striking improvements are due to three factors: (1) To the increased efficiency of burning the coal in the form of dust as compared with burning it on a grate; (2) to the maintaining of a very large mass of charge piled along each side of the furnace, which increases the speed of heat absorption; and (3) to the increased size of the hearth from 112 ft. by 19 ft. to 143 ft. by 21·5 ft.

Conditions which are imperative in order to obtain successful results in coal-dust firing are :—

1. The coal, before pulverising, must be well dried down—*e.g.* to 1 per cent. or even less of moisture. This makes it pulverise better and burn more freely. Nothing is lost in drying it separately, as all the moisture must be evaporated before the coal will burn, and higher efficiency is obtained when the moisture is driven off before using. The furnace itself is the most expensive place in which to dry the coal, as the effectiveness of the whole fire is lowered by the presence of moisture.

2. The coal must be finely pulverised. The increased surface has a direct bearing on the efficiency obtained, and it is well to recognise what this increase is. Mr. Demond has calculated as follows: "The approximate diameter of a lump of bituminous coal is 3 in., and its total surface is one quarter of a square foot, while 1 lb. of coal, ground so that 95 per cent. will pass through a 100-mesh sieve and 82 per cent. through a 200-mesh sieve, has a total surface of 8,000 square feet more or less, depending upon the physical characteristics of the coal, or 32,000 times the area of the single lump."

3. The delivery of coal and air to the furnace must be controlled so that the proper quantity of each may be secured. The proper method of firing pulverised coal is to admit with the fuel the exact quantity of air required for the results to be attained.

4. The coal must contain enough volatile combustible matter to give the required combustion. About 30 per cent. volatile combustible matter is found to be a minimum.

5. The furnace must be properly proportioned and equipped, and in good condition.

6. Provision must be made for removing the ash formed.

Coal Pulverising Plant.—The coal is dumped from 50-ton cars into a receiving bin, from which it passes to two single-roll crushers. These discharge into two manganese steel chain-bucket elevators, which deliver on to a belt-conveyor which, in its turn, discharges evenly into a 1,000-ton steel bin. The coal is drawn from this bin on to a second conveyor belt through automatic feed chutes, that discharge only when the belt is in motion, and passes over a Ding's magnetic pulley to remove all nails, scrap-iron, etc., and is discharged into the boot of an elevator that feeds into three Ruggles-Coles driers fired with pulverised coal. The dried coal is discharged on to three disintegrators which crush to ¼ in. size. A screw-conveyor delivers this product to a steel chain-bucket elevator which discharges into a series of screw conveyors, and these deliver into ten steel hoppers, each of which delivers directly into a Raymond five-roll pulveriser. These are driven by individual 75 h.p. motors, and crush 97 per cent. of their product through 100-mesh. They are operated on the vacuum system. A blower placed above each mill draws the coal from it as soon as it reaches the required fineness and discharges it into a cyclone collector which partially separates the coal and air, the air returning to the mill. The excess dust-laden air from the first collectors is delivered to auxiliary cyclone collectors that discharge into the atmosphere. The dust from all the collectors is delivered by screw conveyors, in air-tight housings, to 50-ton storage hoppers, one at the firing end of each reverberatory furnace. From these hoppers the coal dust is fed into the furnaces through Warford burners, five to each furnace, using air at 16 oz.

* *Transactions* of the American Institute of Mining Engineers, Vol. LI. p. 743.

pressure. The capacity of the entire plant is 1,200 tons of coal per twenty-four hours.

The Warford burner used on the reverberatory furnaces consists of a screw conveyor in an air-tight housing bolted under the discharge opening of the furnace coal hoppers which conveys the coal from the bin to a mixing chamber, where it is thoroughly mixed with the blast air and forced through a 5-in. pipe, which in turn delivers into an 8-in. pipe, and this discharges directly into the furnace. The annular space between the 5-in. and 8-in. pipes allows the necessary secondary air to be drawn in for complete combustion of the coal, and the burners may be regulated to burn any amount from 25 to 130 tons of coal per furnace per twenty-four hours.

The blast air used in the burners is supplied by eight blowers directly connected to individual 75 h.p. motors, and capable of delivering 80,000 cubic feet of free air per minute. Six blowers are in constant operation when eight furnaces are being used. The fuel used is Diamondville coal, containing 41·4 per cent. of volatile carbonaceous matter and 8·1 per cent. of ash. It is blown into the furnace under 16 oz. of air pressure through Warford burners, five to each furnace. The advantages of this method of firing are as follows:—

1. There is a large increase of smelting capacity which makes it possible to smelt the necessary tonnages with fewer furnaces.

2. The efficiency of this method is much greater than that of burning coal on grates. In the latter there is a heat loss in transferring to the hearth the heat generated in the fire-box. This is absent in coal-dust firing, where the combustion occurs over the hearth itself. Another point is that no heat is lost in the gratings from the fire-box, which ordinarily amounts to quite 10 per cent. of the fuel value of the coal. Efficiency is also raised on account of the fact that a uniform temperature is maintained. There are no fluctuations in temperature due to firing cold fuel or to grate cleaning, or to the personal equation of the man firing the furnace.

3. Higher temperatures can be produced and maintained because the quantity of coal burned can be easily increased and there is less excess air to be heated. In grate-firing the excess is about 100 per cent., while in dust-firing only 25 per cent. of excess air is required. Also, as the volume of gases is smaller, they will remain longer in the furnace and give up more heat to the charge.

4. Less draught is required because there is no bed of coal through which air is drawn. This is an advantage because less cold air is drawn into the furnace through the side walls. The following table enables a direct comparison to be made of the two methods of firing over a period of a month, all other factors being kept as constant as possible.

No. 7 Furnace, using Diamondville coal, grate-fired.
„ 8 „ „ „ „ dust-fired.

Furnace.	Tons Smelted per Furnace day.	Total tons Smelted.	Tons Coal.	Fuel Ratio.		
					Excluding Drier Coal.	Including Drier Coal.
7	250·96	7260·31	1870·94	3·88		
8	475·75	14272·52	1984·77		7·19	7·08

It was anticipated that the coal ash might create difficulties in the working of the furnace. This is not the case. The flue connection between the furnace and the two Stirling boilers in tandem through which the gases pass on leaving it is cleaned once each day, and requires the labour of two men from four to six hours per day. Approximately, one-half of the ash floats on, or is absorbed by, the slag and does not interfere with the working of the charge. The remainder is principally deposited in the flues, and very little goes into the boilers. The average temperature of the gases as they pass to the flue is about 880° C. On entering the boilers they develop about 6½ boiler horse-power per ton of coal burned in the furnace, and their temperature is reduced to about 370° C.

The furnaces are charged along the side walls for a distance of 80 ft. from the firing end. The charge is brought in cars on an overhead track and dumped into longitudinal hoppers, from which it is fed into the furnace by 6-in. pipes equipped with slide-gates. It consists of calcine and flue dust, and is kept up nearly to the top of the side walls, thus protecting the

sides of the furnace and avoiding the necessity of fettling. The slag is continuously removed in a small stream; it is granulated by water and sluiced through launders to the dump. Matte is tapped from the skimming end of the furnace. The tap-hole plates are made of copper or cast-iron, and are set in a cast-iron front plate which is water-cooled. The tap-holes are 24 in. below the top of the skimming plate.

In October 1914 the average tonnage per day was 542·7, with a fuel ratio of 7·50.

I come now to the sand-leaching plant, which includes all the buildings and equipment necessary for the roasting and leaching of the mill-tailing, from the old tailing dump, and the recovery of copper and silver values from the solutions. The capacity of the plant is about 2,000 tons dry tailing per twenty-four hours. The tailing is excavated by a clam shell-bucket, and loaded into 50-ton bottom dump steel cars and taken to the unloading station, where it passes through a grizzly on to an inclined belt conveyor, which delivers it into storage bins of 6,000 tons capacity. From these bins it is drawn as required on to a system of belt conveyors that carry it through a tunnel and incline and deliver it into 20-ton hoppers over the roasting furnaces.

The roaster building contains twenty-eight modified MacDougall furnaces. Each furnace has two fire-boxes, one each on opposite sides of the third hearth. The material is given what Mr. Laist calls an "oxychloride roasting." * The roasted material is cooled in a rotating drum and wetted, to prevent dust, before being delivered to a system of belt conveyors that carry it into the leaching-tank building. The latter contains fifteen redwood tanks, each 50 ft. in diameter and 14 ft. deep. Ten of these are for leaching, and have filter bottoms. About 1,050 tons of roasted tailing constitutes a charge. This is distributed evenly over the area of the tank by a drag conveyor revolving about a central axis. Leaching is carried on by downward percolation of a hot solution of salt and sulphuric acid. The addition of the salt is made primarily to dissolve the silver, which would not be effected by the action of sulphuric acid alone. The solution, after passing through the charge, is sent to the solution storage tanks. The tailing from the leach is washed with water and sluiced through gates in the tank bottom into a launder leading to the tailing dump. Five of the tanks in the building are for solution storage purposes, and are at a lower level than the bottoms of the leaching tanks. The solutions are elevated by vertical shaft hard lead centrifugal pumps.

Immediately north of the building are three concrete precipitating launders, each 180 ft. long and 4 by 8 ft. in section. These are kept filled with scrap-iron and strong copper solution from the solution storage tanks is allowed to circulate through them until all the copper is precipitated. The precipitate is taken to the briquette plant and from there goes to the blast furnaces.

Mr. Laist, the metallurgical superintendent at Anaconda, estimated in 1913 that the tailings material could be roasted and leached for not more than 70 cents per ton, which means that copper can be made from tailings yielding only 10 lb. per ton for 7 cents per lb. The recovered silver was estimated to pay for shipping, marketing, and refining, plus about 0.5 cent, making the net cost of the copper about 6.5 cents per lb. Those costs are made possible by the fact that the material in question is already mined, crushed, and sized, that cheap acid is available, made from the roaster gases, and that the operations are on a very large scale. In the experimental plant (an 80-ton per day unit) about 85 per cent. of the copper and 93·5 per cent. of the silver were recovered. Data as to recoveries in the large-scale plant have not been published.

I must, in conclusion, say a word about the laboratory, testing, and research departments. All samples taken in the works, and at the sampling mills, are sent to the laboratory and analysed there for such elements as copper, gold, silver, lead, zinc, iron, lime, sulphur, alumina, silica, and the rarer metals. About 18,000 actual determinations are made each month. The work of the testing department includes the investigation of metallurgical and other technical problems relating to the various operating departments. Its equipment provides for the testing of building materials of all kinds, concentration tests, temperature measurements, gas determinations, measurements of air, water, etc. The research department does all the experimental work connected with new processes, and puts them on a commercial working basis before turning them over to the operating department. Complete laboratory leaching and flotation apparatus are parts of this equipment. In addition there is a large assembly room, where meetings relative to the operation of the plant

* Full details are given in the *Transactions* of the American Institute of Mining Engineers, Vol. XLVI. pp. 362–377.

are held, and discussions take place. It has the equipment of a good lecture room.

Some years ago a "Safety First" department was instituted, and this has become a permanent feature of the works organisation. Committees have been appointed to discuss methods of providing safer and more healthful working conditions for the employees. There is a permanent general committee, composed of officials of the company, and there are departmental committees composed of members of the operating staff. The head of each department is the permanent chairman of that committee; the other members are changed once in three months. The office of safety engineer has been created, and a magazine—*The Anode*—is published monthly to offer helpful suggestions and to record what is being accomplished by this and other similar departments. Each department has a bulletin board for illustrations of causes of accidents and methods of their prevention. Departmental first aid teams have been organised, and competition between them is very keen. A completely equipped department to deal with fire outbreaks is maintained.

Finally, permit me to record an incident during my visit to Anaconda. The general manager, Mr. Mathewson, received me very kindly, and when he was about to take me round the plant he said: "We quite understand that you are not an expert on the practical side of the metallurgy of copper, but *we don't consider we know everything here;* and if in the course of your stay with us you have any suggestions to make with regard to what appears to you to be possible improvements in our methods or processes, we shall be most pleased to consider them." I have visited many other works in the course of my life, in this and other countries, but I cannot remember having had a remark of that kind made to me at any of them. I venture to suggest to you that there is a direct connection between the attitude of mind revealed in Mr. Mathewson's request and the high degree of efficiency and skill which characterises every department in the Anaconda works. I will go even further, and say that, in my opinion, the connection is one of cause and effect, and that the future lies in the hands of works which are conducted in this spirit.

I had hoped to deal briefly with present-day practice in the extraction of native copper at Calumet, in pyritic smelting at the Tennessee Copper Company, and in leaching at Chuquicamata. Time presses, however, and I must confine myself to a brief reference to the last named, whose special interest lies in the fact that electrolytic copper of a high degree of purity is obtained from the ore in only three stages.

The mine of the Chile Exploration Company, situated at Chuquicamata, is, as regards tonnage and contents of valuable metal, one of the greatest known copper deposits in the world, and is unique in that its principal copper mineral, brochantite, is mined on a commercial scale in no other locality. This property is situated on a branch of the Antofagasta and Bolivia railway, about 160 miles north-east of Antofagasta. The high point of the mine lies at an altitude of 9,890 ft., while the extraction plant lies 9,023 ft. up. Deposits were worked by the ancient Indians long before the Spanish conquest. They used the minerals atacamite and brochantite for ornamental purposes rather than for general utility. Later on the Spaniards operated the mines in a small way, and in recent years English and Chilian companies have done a considerable amount of mining both underground and in open pits. In 1912 the property was acquired by the American firm of Guggenheim's, and drilling was started. Three years and one month later the plant was started on a commercial scale. In that time the mine was opened up for steam-shovel mining, a railway for transportation of the ore was built, and a plant of 10,000 tons daily capacity was designed and erected in a desert 5,000 miles away from the base of supplies.

The ore reserves on April 25th, 1915, were estimated as follows:—

	Tons.	Percentage of Copper.
Oxidised ore .	204,384,409	1·952
Mixed ore . .	65,787,332	2·983
Sulphide ore .	33,129,047	2·477
	303,300,788	2·233

say, 2·00 per cent. of copper.

The total copper reserves are, according to this estimate, more than six million tons—truly a colossal figure, and one estimated by Mr. Pope Yeatman, the company's engineer, to be well within the mark.

A typical analysis of the oxidised ore is as follows:—

Moisture	0·30	per cent.
Silica	67·48	,,
Lime	0·61	,,
Copper oxide (CuO) . .	2·66	,,
Chlorine	0·40	,,
Nitric acid	0·05	,,

(SO_3)	Sulphuric acid	1·76	per cent.
	Sulphur (sulphide)	0·03	,,
	Alumina	13·39	,,
	Ferric Oxide	1·86	,,
	Magnesia	0·24	,,
	Manganese dioxide	0·02	,,
	Sodium oxide (Na_2O)	3·46	,,
	Potassium oxide (K_2O)	0·84	,,
	Loss on ignition	6·80	,,
	Total	99·90	

The ore near the surface is higher in chlorine and nitrates. What makes the process chosen particularly applicable for the Chuquicamata ore is the fact that it carries itself more than enough sulphuric acid for the solution of the copper, and that on precipitation of this from the solution more than sufficient acid for the leaching of the next batch is regenerated, which allows the discarding of solutions if necessary, and thus avoids their fouling by continual use.

Experiments proved that very little iron, silica, or alumina goes into solution, and that it is possible with the average ore to use the same solution as many as a hundred times without ill effect. The method of extraction was worked out under the direction of Mr. Cappelen Smith. Briefly it is as follows :—

The plant is designed for a capacity of 10,000 tons of average grade ore per day. The latter is crushed to about ½-in. mesh, and leached with sulphuric acid. The greater part of the chlorine is eliminated by treatment in tube mills with metallic copper. The remaining copper is precipitated from solution by electrolysis, and the cathodes are melted into commercial bars. The cuprous chloride formed in the dechloridising drums is worked up into copper, either by smelting or by dissolving the chloride in salt and electrolysing, or by precipitating as cement copper with scrap-iron. In the original plant magnetite anodes were used in the electrolytic process. They proved very brittle and numerous breakages occurred. A substitute which has proved satisfactory on the whole is duriron, a high silicon iron alloy. It is not entirely unacted on, but from fifteen to twenty times its weight of copper can be deposited before it is corroded away. Duriron anodes have an advantage over magnetite in their mechanical strength, but they have a much higher over-voltage, which is a decided disadvantage, and about 15 per cent. more electrical energy is required for the deposition of the same quantity of copper. The conductivity of the copper produced is from 100·5 to 101 per cent. Matthiesslu's standard.

A very good description of the metallurgical operations of the plant is given by Mr. Rose in the *Engineering and Mining Journal*, 1916, pages 321–326. The particular interest attaching to the processes at Chuquicamata is that for the first time, and on a really large scale, lixiviation and precipitation methods have been adopted for the extraction of copper in a way which recalls those in use for that of gold and silver. From start to finish the process is one of hydrometallurgy, and pyrometallurgical processes—apart from one alternative method of working up the cuprous chloride—are entirely absent. Although the operations of the plant have not yet been brought up to the anticipated capacity of 10,000 tons per day, this is not on account of any basic defect of the process, but is rather due to the usual troubles encountered in starting any new metallurgical plant.

A few words in conclusion as to present-day tendencies in the metallurgy of copper. I think I cannot do better than quote some words recently written by Mr. Lawrence Addicks,* one of the foremost copper metallurgists in the world. He writes :—

"The unprecedented market for copper during 1916 has given a tremendous stimulus not only to the production of the metal and consequent expansion of the reduction plants, but also to the further development of the metallurgy of lean ores. . . . A table of average contents of ores treated in the last ten years would show an astonishing diminution year by year, and with the increasing attention to the recovery of by-products such as sulphuric acid and some of the minor metals associated with copper, it will soon be difficult to define a copper ore at all. The advance in copper metallurgy in 1916 may be briefly summarised as having been striking in three directions : Flotation, leaching, and sulphuric acid manufacture from smeltery smoke, all of which are more or less closely inter-related. Flotation and leaching, though far apart at one end of their application, rub elbows rather closely at the other end, and sulphuric acid—which can be produced so cheaply as a by-product from waste gases at a neighbouring smeltery—has become the desideratum of the leaching plant. . . .

"The revolutionary effects of flotation continue to be felt in both ore dressing and smelting, as shown by the development of fine-grinding machinery, and of methods of drying and smelting concentrates of excessive fineness. The

* *Engineering and Mining Journal*, 1916, pp. 51–52.

whole flotation question appears to be clarifying. On the theoretical side the controversy as to its *modus operandi* has led to a general investigation of the application of colloid chemistry, which is yielding many data of value in other lines. . . . Practically the possibilities and limitation of flotation as a metallurgical process are more clearly understood than they were a year ago. What it can do on a sulphide ore is shown by the increase in the concentrates recovery from 82 per cent. under the highly developed methods of the old wet concentration to 96 per cent. after adding flotation. On mixed sulphides and oxides the feeling is now that the latter can be better handled by a separate hydro-metallurgical treatment. When acids and soluble sulphides are added as flotative agents with the object of coating oxidised material, flotation is really sailing more or less under false colours, as most of the additional recovery seems to be due to the dissolving of copper in the acid, and subsequent precipitation as sulphide which is straight leaching; and as these reagents tend to react rather unfavourably on the legitimate recovery of the sulphide minerals present, it appears that the leaching operation should be conducted separately.

"The clearer conception of the limitations of flotation methods already mentioned has led to a renewed interest in leaching, which for a time had suffered from arrested development. The companies in the south-west producing concentrates with some oxidised values, are practically all experimenting along leaching lines for the recovery of these values. One scheme that seems to have possibilities is that of dissolving these values in dilute sulphuric acid and then precipitating them upon iron, recovering the cement by flotation without any attempt to separate the liquid from the pulp. This avoids having to meet the difficult question of filtration or otherwise dewatering a more or less colloidal slime. Flotation is also being considered as an adjunct in the Lake Region, and while a year ago it appeared that flotation controlled the sulphides and leaching the oxidised propositions, and that the mixed ores would be fought for by the two methods with a strong leaning towards the former, it now seems probable that this middle ground will be handled by both methods used on complementary rather than competitive flow sheets.

"The exceedingly fine state of physical subdivision of flotation concentrates, together with the large and increasing tonnage produced, has introduced problems in treatment which are bringing about a general overhauling of methods. While a reverberatory thrives on fine material, even it expresses some surprise at a charge running from 100 down to 500 mesh. This has caused the possibilities of leaching to be considered as a means of treating the concentrates themselves, and it is quite possible that the metallurgy of copper may develop along quite new lines in the next few years."

You will see, therefore, that the general trend of the metallurgy of copper in most recent times has been towards a substitution of pyrometallurgical by hydrometallurgical methods, and it is to be expected, in view of the decidedly promising results which have been achieved, that this tendency will be still further accentuated. If such proves to be the case, the similarity between the methods of extraction of copper on the one hand, and gold and silver on the other, will become more and more pronounced, and the significance of this should be realised, for it will mean that the copper industry has reached a level of uncommonly high technical efficiency. The great importance now attached—and rightly attached —to the necessity of working the ores, not only for their copper values but for *all* values which they contain, is also of a significance not easily to be exaggerated, because it involves the conclusion that a far wider range of raw materials will be brought within the scope of economic exploitation than would otherwise be the case. It can hardly be doubted that within a short time certain ores containing not more than 1 per cent. of copper will be worked for that copper. Not only therefore will it be possible, owing to increased extractions, to conserve the world's ore resources, but the life of the industry will thereby be correspondingly lengthened and thus rendered more stable. And even though it is the case that the centre of gravity of the industry is in the United States of America, and perhaps is destined to stay there, we in this country may feel a legitimate pride in the fact that the genuine pioneering work of such men as John Holway in pyritic smelting and the Bessemerising of mattes, Parkes, and later the MacDougall brothers, in the design of roasting furnaces, Elkington in electro-refining, Oliver Lodge in electrostatic precipitation, and most recently of all Sulman and Picard in flotation, has had a revolutionising and most beneficial influence on the scientific development of that industry.

SIXTH ORDINARY MEETING.

WEDNESDAY, JANUARY 16th, 1918; SIR FREDERICK BRIDGE, C.V.O., Mus.Doc., Organist to Westminster Abbey, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Armstrong, Lieut.-Colonel J. A., R.E., London.
Ashford, John, M.I.Mech.E., India.
Brecknell, Henry Edwin Frank, Bristol.
Brown, Lieut.-Colonel F. Leslie, D.S.O., South Africa.
Bunker, George R., New York, U.S.A.
Butcher, Arthur Douglas Deane, Egypt.
Butler, William, Pennsylvania, U.S.A.
Carnt, Engineer-Commander Albert John, Peterborough.
Carruthers, Engineer-Captain David John, R.N., Sevenoaks.
Dommett, Lieutenant William Erskine, R.N.V.R., Bedford.
Geejgarh, Chief of (Thakur Sahib Kushal Singh), India.
Gill, Harry, Kinlochleven, Scotland.
Graham, Alfred H. Irvine, Assoc.M.Inst.C.E., Surbiton.
Heckford, Arthur Egerton, Birmingham.
Hood, James Maclay, Glasgow.
Hugon, G. R., Manchester.
Hunter, Sir John, K.B.E., Dumbarton.
Hurren, Frederick Harold, Coventry.
Ingle, W. L., J.P., Leeds.
Kemp, Henry Thomas, Abbey Wood.
Kreglinger, Albert, London.
Leigh, E. B., Chicago, U.S.A.
Maxwell, Robert W., Surrey.
Morch, Jacob, London.
Owen, Alfred Ernest, Darlaston.
Pearson, John Andrew, Toronto.
Pierce, Edward Lily, Syracuse, U.S.A.
Pinckard, Mrs. R. A., London.
Richardson, Ralph, Weybridge.
Saunders, Samuel Edgar, M.I.N.A., Isle of Wight.
Scott, Thomas Henderson, Assoc.M.Inst.C.E., Trinidad.
Simms, William Archerr, Swansea.
Smith, Major S. Heckstall, London.
Tucker, Percy Earle, Yeovil.
Twiggs, Alderman H. W., Bristol.
Waddington, George, London.
Wakefield, Alderman Sir Charles Cheers, Bt., London.
Walker, Henry T., London.
Welch, Henry John, Bromley, Kent.
Wilkinson, Samuel Blaze, Northampton.

The following candidates were balloted for and duly elected Fellows of the Society:—

Barnett, Samuel, London.
Bewsher, Joseph Ponsonby Horatio, Croydon, Surrey.
Bradley, Major Benjamin, Harpenden.
Carter, Wilfrid George, Kingston-on-Thames.
Connal, Allan Ramsay, A.M.I.E.E., East Sheen.
Copley, J. W., Caterham.
Crewdson, Alfred, Alderley Edge.
Foley, Gerald Henry, R.F.C., London.
Gourlay, C. G., London.
Haslam, William Gilbert, J.P., Derby.
Haynes, Ernest, London.
Lyddon, George Edward, A.M.I.Mech.E., London.
Matthey, George Cowper Hugh, London.
Murphy, William Bernard, Peterborough.
Rawlinson, H. W., London.
Smith, Henry White, Bristol.
Smith, John Sugden, Bradford.
Stewart, Samuel, London.
Thornton, John Edward, London.
Walsh, Frank Ford Peregrine, F.R.G.S., London.

The paper read was—

THE BRITISH PIANOFORTE INDUSTRY.

By DR. REGINALD S. CLAY,
Principal of the Northern Polytechnic Institute.

Music is, perhaps, the oldest of the Arts. We read, for instance, of "Jubal, who was the father of such as handle the harp and organ," and stringed instruments played with the hand are undoubtedly very ancient. They appear on Egyptian sculptures, and one at least has been found in an early Egyptian tomb still retaining some of the strings intact. The keyboard was at first applied to the organ, possibly as early as the second century, although this is uncertain. The small portative organs with keyboards were certainly in use in the thirteenth and, perhaps, twelfth centuries for processional work in the churches.

Towards the end of the next century two-stringed instruments—the exaquir, or echiquier, and the doucemelles—were made, almost certainly with a keyboard, and, if so, these were the parents of the modern piano. They were followed by a series of better known instruments. The first of these, the clavichord, was invented, apparently, somewhat before 1500. In this instrument the string was struck by a tongue, called a tangent, which was held against the string so long as the sound was desired to

be maintained. The tangent formed a temporary bridge, the string vibrating between it and the bridge on the soundboard. Beyond the tangent the string was permanently damped by a narrow band of soft stuff, so that as soon as the tangent was removed from the string the sound ceased. The wires were all brass, apparently of equal length; there were several soundboard bridges; and more than one tangent struck the same string at different distances from the bridge, and so produced notes of different pitch. Thus there were more keys and tangents than there were strings. A true vibrato effect was possible with this instrument.

The second instrument was the virginal, or spinet, in which the sound was produced by plucking the wire with a piece of quill. This also dates from the end of the fifteenth century, and may be older than the clavichord. The immortal Pepys bought a spinet in 1688. He says: "At noon is brought home the espinette I bought the other day of Haward costs me £5." Other English makers were James Hitchcock and Keene. The spinet was a comparatively small instrument with the strings running more or less parallel to the keyboard.

In the third of these early instruments, the harpsichord, the strings ran at right angles to the keyboard as in the ordinary straight string grand piano, and the shape of the instrument was very similar to that of the grand. The sound was produced in the same way by plucking the string. This method of producing sound continued for three centuries. It is, of course, obvious that no variation in intensity could be produced by striking the key harder (as in the ordinary piano); so, in order to give variety in the harpsichord, stops were added by which, on the striking of a key, different sets of jacks could be brought into play which plucked other wires which might be the same pitch or a pitch an octave higher, or even occasionally an octave lower; also leather was sometimes substituted for the quill to produce a softer tone, and the more costly had two keyboards. Venetian shutters were added to vary the loudness. There is a fine example, dated 1521, in the South Kensington Museum. The great harpsichord-makers of this century were Burkhardt Tschudi and Jacob Kirchman, both of London, the founders of the houses of Broadwood and Kirkman. These instruments continued to be made up to the end of the eighteenth century.

The piano itself was invented about 1709 by an Italian, Cristofori, who was a musical instrument maker to the Duke of Tuscany. It was fully described in the *Giornal di Litterati d'Italia*, Venice, 1711. It was invented, no doubt independently, by a Frenchman, Marius, in 1716, but his action does not appear to provide any means for preventing the hammer remaining in contact with the string after the blow was struck.

A third inventor was Christopher Schröter, in 1717. His action had no hopper, the travel of the key was limited, the hammer finishing the last quarter-inch of its movement by its own inertia, so that the touch must have been poor.

The Cristofori piano apparently died out in Italy, but Gottfried Silbermann, of Dresden, Saxony, possibly a pupil of Cristofori, started making these instruments in Germany, copying the Cristofori piano exactly. The Seven Years' War (1755–62), through the devastation of Saxony, destroyed the industry, and twelve Germans—called, according to an old shop tradition, "the Twelve Apostles"—landed in England about 1760, among them being Zumpe, Backers or Beckers, and Geib. These helped to found the piano industry in this country. Zumpe designed the square piano, of which he sold great numbers. The action was a very simple one, and the instrument was sold at a comparatively low price. Kirkman, who had started in England in 1740 as a harpsichord-maker, also took up the manufacture of pianos about the same time. He died in 1778 worth nearly a quarter of a million. Evidently the trade was a very lucrative one in those days. So also did Tschudi take up the manufacture of pianos. He was born at Schwanden in Switzerland in 1702. He came to London in 1718 as a cabinet-maker, and he entered the firm of Tabel, who was a harpsichord maker. In 1732 he started on his own account at 33, Great Poultney Street. Early in the fifties John Broadwood, who was born at Cockburnspath in Scotland in 1732, and was a joiner by trade, entered his factory. He was evidently a valuable asset to the firm, as he was shortly after made a partner and married his employer's daughter. He was a man of great ability and distinction; he kept open house, at which the musicians and other artists of the day congregated. He was one of those who appreciated the value of science, using Dr. Gray and others to assist him in improving his pianos. In 1795 he admitted his son, James Tschudi Broadwood, to partnership. He died in 1812 at the age of eighty. His grandson, Henry Fowler Broadwood, was another who greatly assisted in developing this firm, and he also died at the great age of eighty-two in 1893.

Another of the oldest firms responsible for the development of the British piano industry is that of Collard and Collard. This firm has grown out of that of Longman and Broderip, which was established in 1740 as a music publishing firm. They were joined and ultimately taken over by Muzio Clementi, the composer and virtuoso. Later, he associated himself with F. W. Collard, and, when he retired, the firm became Collard and Collard. The inventive genius of F. W. Collard, joined with the musical criticism and the reputation of Clementi, made the rapid progress of this firm. Other old firms were Challen, established 1804 by William Challen, a member of an old Sussex family, whose genius for mechanical work impelled him to try his fortune in London, where he started in Great Titchfield Street, in partnership with a Mr. Hollis, as a piano maker, followed by his son, Charles Challen, who lived till 1909; Chappell and Co., 1810; Eavestaff and Sons, 1823; Cramer and Co., 1824; Pohlmann and Sons, 1828; B. Squire and Sons, 1830; Rogers and Sons, 1834; Hopkinson, 1835; Strohmenger, 1835; J. Brinsmead and Sons, 1837; and Allison, 1837.

The number of firms engaged in the industry has slowly increased, until there are at the present time over one hundred and thirty pianoforte manufacturing firms in England, not including the large number of firms engaged in the construction of special parts, as, for instance, the action, keys, iron frames, wrest pins, wires, etc. The action and key makers usually supply the piano manufacturers direct, but in the smaller parts the manufacturers deal through the supply houses. The majority of the pianos naturally are sold to the public by dealers, of whom there are, of course, a large number in every town of any size, and the total of these is therefore very much greater than the number of piano manufacturers, so that the industry is one of considerable importance.

I have not been able to obtain statistics showing the growth in the output of British pianos from the commencement, as I had hoped might have been possible, but from the Census returns I find that in 1911 in Great Britain there were 14,115 men and 312 women engaged in the manufacture of pianos and organs. The total number engaged in the manufacture of musical instruments in the same year was 15,889 men and 565 women. The Census returns before 1911 do not separate those engaged on musical instruments, but as the above figures show that the piano and organ firms employed the bulk of the labour, the statistics for the musical instruments generally must obviously show pretty closely the growth of the piano industry. These figures which are shown on the screen date back for the last sixty years:—

Musical Instrument Makers and Dealers (England and Wales).

Men and Boys.

1861.	1871.	1881.	1891.	1901.	1911.
5,079	7,156	9,008	12,174	13,747	15,889

Women and Girls.

1861.	1871.	1881.	1891.	1901.	1911.
89	183	241	449	342	565

In 1913 the total pianos sold by the English piano manufacturers amounted to 117,665, of which 9,251 were exported and 107,814 were sold to the home market.

The number of men employed by the piano manufacturers was 9,750. This number does not, of course, include those engaged in the subsidiary trades, which accounts for the greater part of the difference in the figure and the 14,115 mentioned above. The retail value of the instruments was, roughly, about £4,000,000.

According to an old book, the number of pianos made in 1851 was 23,000, valued at £1,000,000; in 1853 the number increased to 27,740, valued at £2,840,000. It is stated that there were 200 makers, and that there were forty separate branches of the trade. The total tension of the strings is given as between 11 and 12 tons.

Our great competitors up to 1870 were the French. For instance, in 1863 the value of the pianos imported from France was £103,458 out of a total import of £111,228. The total number of pianos imported in 1865 was 2,421, and by this year the total value of the imports had fallen to £66,772, and by the following year it had again fallen to £32,215. The Board of Trade did not give the value of the pianos imported separately from the musical instruments between 1870 and 1904; but by the latter date it had increased some tenfold to £648,701. It continued to increase up till 1906, reaching a maximum then of £706,244; in 1909 it declined slightly to £569,250, rising again to just over three-quarters of a million sterling in 1913.

Some statistics of the imports and exports have been kindly prepared for me from the Board of Trade returns by Mr. White.

The total number of pianos made in 1860 was stated by Edgar Brinsmead, in his book published in 1870, to have been 35,000. So that, even in spite of the foreign competition

and the lack of initiative of the British manufacturers, the trade has very considerably increased in the last forty years; but I venture to say that that increase is not nearly as great as it might and should have been. The export trade in particular is almost insignificant. According to Dolge, the output of American pianos in 1911 was 350,000, and of German 170,000, of which 20,000 were exported to England.

The manufacture of the pianoforte appears to have been a very healthy industry. I have already mentioned the names of two makers who passed the age of eighty, and the Census returns giving the ages of those engaged in the trade are interesting, especially when it is to be remembered that in 1911 the pernicious system of seasonal employment for the workmen was the practice in a large number of firms—that is to say, that these firms, instead of maintaining a steady output through the year, ran their factories at a high pressure for six months and then paid off a large number of their hands. Obviously such a system would very greatly deter good men from taking up the trade.

AGES OF EMPLOYEES IN PIANO AND ORGAN FIRMS IN LONDON IN 1911.

Men.

Under 15	15	20	25	35	45	55	65-75	upwards.
79	729	694	13,999	1,084	823	519	234	47

Women.

Under 15	15	20	25	35	45	55	65-75	upwards.
8	63	42	27	10	3	4	1	—

These were distributed as follows:—

	Employers.	Workmen.	On own account.	Others.
Men . .	178	4,943	360	141
Women .	—	140	5	8

The English square piano was, as I have said, introduced by Zumpe between 1760 and 1765. The action was a very elementary one, as you have seen. Broadwood improved the piano by moving the wrest plank from the side to the back, but he still used the same action. It was John Geib, another "apostle," who in 1786 re-introduced the hopper invented by Cristofori and applied it to the square piano; pianos with this action were first made by Longman and Broderip. About the same time Backers invented the so-called English action which, developed by Stodart and Broadwood, remained almost unchanged in England for nearly a hundred years—in fact, long after the beautiful action invented by Sebastian Erard in 1823 had been universally adopted abroad.

The use of a single wire double length to serve as two strings was invented and patented by Collard in 1827. About the same time the down bearing was introduced, that is to say, the bending of the wire as it passes over the bridge so as to produce pressure on the soundboard. The repetition movement was patented by Broadwood for their grand action, invented by Southwell, an Irishman, who had previously invented the Irish damper.

I might point out, in passing, that the question which has come to the fore again as to the possibility of affecting the tone by the method in which the key is struck, was discussed as early as 1854, when Dr. Lardner said: "the keys can produce no effect whatever upon the string, except by imparting more or less projectile velocity to the hammer. The player may work his hands and his arms, he may raise them two feet above the keys and throw them down upon the keys; he may gesticulate as though he were engaged in a Herculean task, but the strings will not sympathise with his struggles, and will respond with no more effect than they would if the keys were put down with the same celerity and promptitude by the fingers of an infant."

The modern upright piano was the invention of an Englishman, John Isaac Hawkins, who had migrated to Philadelphia. He patented it in 1800. Up to this time the upright pianos had, like the upright spinets and harpsichords, been merely horizontal instruments turned up on the broad end on a stand. In Hawkins's piano the strings descended below the keyboard, and the bottom of the instrument was upon the floor. There was a complete iron frame, within which the belly was suspended independent of the case. It was full of new ideas, including a hopper action, iron rods at the back to balance the strain of the wires, and a system of tuning by mechanical screws.

The upright pianos were mostly fitted with the sticker action invented by Southwell in 1807.

The action now used in all upright pianos was the invention of an Englishman, Wornum, in 1826. But again the sticker action of Southwell was adhered to in England long after the Wornum action had been almost universally adopted abroad. Wornum made an upright piano in 1811 with diagonal strings. Another great improvement that we refused to accept for many years was the iron frame, although we appear to have been the first to use iron to strengthen the wood frame. This conservatism seems to have paralysed the improvement of the piano for at least thirty years. Up to 1860, or even 1870, we were well to the front, and most of the improvements were due to

English firms; but, in common with many other industries, we allowed this one also to fall behind during the last part of the nineteenth century. The first seventy years of that century is one we can look back upon with pride. The application of the steam engine, which Watt had made efficient, to engineering, to textiles, to locomotion, and to industry generally, associated with the names of Murdoch, Stephenson, Brunell, Arkwright, and Compton; the developments of electricity associated with Faraday, Wheatstone, Kelvin; the supremacy which we had at sea, the development of our Colonies, and the general prosperity of the country, had brought fortunes to the men who owned businesses. The men who had originally built up the businesses were gone; their descendants were some of them old men, who had grown into ruts and would have no changes; or, if young, they had come into the business with little knowledge of the practical side and still less of the science which underlay it, and with no appreciation of the value, nay, the necessity, of the assistance of science if the business was to progress. Our competitors abroad, on the other hand, both on the Continent and in America, were fully alive to the aid which science could render. The results of this disastrous blindness in the chemical, optical, and even electrical engineering industries, were acutely realised almost immediately after war was declared. All this is almost equally true of the piano industry. This has grown continuously up to the date given with little foreign competition, and the larger firms in the industry had realised large fortunes. The industry has indeed continued to grow since, but not to the extent it should have done, considering the great demand that the spread of education had produced, so that not only the middle class, but even the artisan home has grown to be incomplete without its piano. It was not until our markets had been seriously invaded that the English firms realised that they must change their methods and adopt the improved actions, iron frames, higher tensions with wires of better quality, and the general improvement in tone, that their competitors had evolved. In fact, we were behind, and whereas formerly the improvements in piano construction had, during the first part of the century, for the most part originated here and been copied abroad, during the last fifty years they have mostly originated abroad and been—sometimes after a long interval of time—copied here. I am sure you will all agree that this must be changed. I am glad to believe that the manufacturers have realised this and are making every effort to alter it. Especially since the war they have been combining together to raise the status of the English trade, but I am glad to think that for the last ten or fifteen years we have begun to wake up and to regain our old position. In order to do this we must have the co-operation of the musical profession. Let me give you an extract from an American Consular report on the trade in Russia. He says: "The music teachers, as well as the piano dealers and tuners, are principally Germans, and they invariably recommend German instruments and earn a liberal commission thereby. According to a former professor of the Moscow Conservatory of Music, the profits on German pianos are 40 to 100 per cent." I believe a great deal of this was true of England before the war. It is well known that singers and artists found it paid to adopt foreign names, and a prejudice had been equally created largely by the means I have just referred to in favour of the German piano. This must be broken down. We want the musicians to examine the modern English pianos without prejudice, and to help the makers by definite helpful constructive criticism, and by recognising and approving, at least as cordially in a home product as in a foreign one, merit when it exists.

One factor which has helped to give the English piano a bad name, is the limited musical training of the average buyer. The great majority of people are quite ignorant of the musical value of a piano, and there is thus every inducement to supply them with the instrument on which the greatest profit can be made. Many export merchants, asked by their clients to supply a piano, have yielded to the same temptation, so that a type of piano, which is little more than a case with tricks, has been made and sold in great numbers. Many of these have found their way abroad, to the discredit of the British piano as a whole. It has therefore been proposed that powers should be obtained to lay down some minimum standard that should be attained before a piano may be exported. Such a scheme would insist on the use of good and properly seasoned timber, that the several parts be well made, especially the back, wrest plank, soundboard, and iron frame. The keys, actions, case, and finish should also reach certain standards. Whether this scheme will be adopted remains to be seen, but the fact that it has been even suggested is worth noting. Such a scheme would enable the conscientious makers and

dealers—who, I am satisfied, are still in the great majority—to trade on fair terms.

Another scheme which aims at the same result was very ably put forward by Mr. Dow, at the Congress of the Music Trades at the Midland Hotel in July last. He suggested that every piano which reached a standard to be agreed upon should be entitled to have appended to it a label, just as gold and silver are given a hall-mark. A small charge for this label was proposed, which would, even on a basis of half-a-crown per piano, bring in a fair income. He proposed to use this income to provide an office and clerical staff for the use of the trade, to assist in marketing the British piano abroad, for a benevolent fund, for research work, and for prizes. This was approved, and the council was asked to prepare a scheme to be submitted to a general meeting of the makers.

The suggestion seems to me one with great possibilities. It has two initial difficulties to encounter in opposite directions. The firms who have made their reputation by consistently supplying a sound instrument do not need the label, and feel that it would allow firms who have not in the past been careful about the quality of their materials and workmanship to reap where they have not sown; and of course the firms making the poor quality piano it is attacking may be expected to oppose it quietly but none the less strenuously. The latter opposition need not be feared, and I hope that, by some modification of the scheme, it may be possible for the well-known firms who are, of course, in sympathy with the objects to be attained, to come into the scheme, as it is obvious that without them it is foredoomed to failure. I should like to see the half-a-crown made into five shillings, as I am sure that the income, if rightly used, would repay the trade a hundredfold.

Another scheme the manufacturers have been considering is the standardisation of the piano. Ever since the invention of the steam engine there has been an increasing tendency to substitute the machine for the man in the production of wealth, and by this substitution in agriculture, and in industry, the necessities of life, food, clothing, etc., can now be produced with a fraction of the labour that was required at the beginning of the century, and the surplus labour set free has become available for the production of articles of luxury. The working hours have also been able to be reduced, and will no doubt continue to be shortened as time goes on. This tendency is one which will probably become effective at an increasing rate after the war, when fierce competition will ensue for the trade of the world, and only those nations which, by the utilisation of every improvement in the means of production, are able to sell their articles at the lowest price, will necessarily and rightly gain the ascendency in this commercial war. Thus, unless we are prepared so to standardise our manufacture that our pianos of each quality can be made mainly by machinery, we shall not be able to hold our position. This, of course, applies so far as the construction and mechanism are concerned, for it must be remembered that the piano is not a mere piece of furniture nor yet a machine; it is a musical instrument, and there is still what I might call the soul of the piano to be retained. Here the human element comes in, and the accumulated experience of our makers must be utilised and developed with the aid of science in the production of a correct design and in the final perfection of the tone of the instrument; but in the actual constructional work—in the making of the frame, the back, the action, and the case, machinery must be utilised to the fullest possible extent. It is sometimes supposed that a hand-made article is essentially better than a machine-made one. This is a fallacy which the war has proved in the case of our engineering trades, and which I venture to say competition will prove after the war in all trades where machinery can be employed—amongst them the piano industry. As a rule, wood-working machinery has been badly made, and the results obtained have, therefore, not been satisfactory; but if wood-working machines are as well made as engineering machines, and if the tools are kept perfectly sharp and run at a sufficiently high speed, beautiful results can be obtained. To employ machinery economically standardisation is essential, and firms must be prepared to co-operate with one another. Our English manufacturers almost universally have been too ready to make every variety of article. Grands and uprights, cheap and expensive, are made by almost every firm. There is no reason why there should not be a variety in unessential parts—in the case, for instance—but manufacture that is to compete in the future successfully will have to be on a large scale. The smaller firms can only achieve this by combining together, using central factories to manufacture the essential parts, and themselves assembling, finishing, and regulating them.

Any such factory should be designed for an output of at least one thousand per week, and

the workmanship even of the lowest grade piano must be of very much higher grade than it has been in the past. This necessitates thoroughly efficient up-to-date machines, well made, and with suitable arrangements for keeping them in first-class condition. For this an amply equipped tool-room is essential. In particular, cutting tools must be kept absolutely sharp, and the American practice of sharpening all tools in one central tool-shop should be adopted. Much more attention should be paid in the design of wood-working machines to improving the facility with which the tools may be sharpened. I would suggest, for instance, that, as far as possible, the tools should be mounted on standard Morse-taper spindles, as in the modern engineering milling machine, so that the spindle may fit any machine, and that the whole spindle may be withdrawn with its cutters and sent to the tool-room, where it can be sharpened and set to a gauge. A sufficient supply of cutters should be available, so that the machine-minder could at once be able to replace one if the edges are blunt. All work should be done to gauge, so that assembling may be carried out without any hand-fitting being necessary. Firms on war work will understand what this means.

Still another experiment, which is already in being, is a most interesting one. I refer to the apprenticeship scheme. Owing to the foresight and pertinacity of a few of their number, who realised the importance of a better type of foreman and workman in the factory, and who urged this matter upon the general body of the trade at the annual conferences of the association, the British piano manufacturers have been the first of any of our great industries to organise themselves for both commercial and educational purposes, and the apprenticeship scheme which they have evolved will always stand as a pioneer scheme, which is already being imitated in a greater or lesser degree by other industries, and has aroused a good deal of interest amongst educationalists. Every apprentice under this scheme is taught the general scientific principles, and a general outline of the practical manufacture of the piano throughout, at the Northern Polytechnic, which is situated at or near the centre of gravity of the trade in London. Each apprentice during the first year of his apprenticeship, spends half the week at the school and the other half at the works. During the other four years of the apprenticeship he spends one whole day a week at the school. The curriculum at the school includes mathematics, English, science—especially mechanics and sound—geometry, and trade work. Each group of boys in the second year begins the actual construction of a piano, and it is hoped that this piano will be completed during the course. Thus they will have a practical acquaintance with every operation involved in its manufacture, and if there are among them any inventive ones or any with special ability, they will have the requisite groundwork, both theoretical and practical, to equip them to improve the instrument. Even if there are none of these among them, they must surely make more intelligent and therefore more valuable workmen, and they should rise to positions of responsibility, when they will amply repay the cost and trouble of their training. I have very great faith in such a training. I believe it is far more likely to be successful than the old apprenticeship system, under which a boy was put with a man, picked almost at haphazard, to learn his trade. When it is remembered how few men know why they do any process in a particular way, and how still more infrequent is the man who can explain intelligently why he does it, it is almost wonderful that a boy learnt anything at all. They very often really did learn very little beyond the mere mechanical handling of the tools. But at a school the teachers are specially selected, the courses are carefully thought out so that every task shall teach something, and the boy is not merely making himself useful. Thus the large amount he should, and I may say does, learn, even in the small proportion of the time he spends at the school is easily accounted for. I have watched the results in the case of the building trade scholars of the London County Council, and have no hesitation in saying that at the end of the three years' full-time course which their scholarship provides, they are far and away better than boys who have spent the same time as ordinary apprentices. Unfortunately the war is interrupting all this work at present.

In still another way the piano manufacturers are endeavouring to make up for lost time, and to put their work on a sure foundation. I allude to the establishment of a school of research in connection with the piano. They have guaranteed an income in the first instance for three years to enable this to be carried on, and the Industrial Research Committee is supplementing it. It is naturally almost impossible at present to obtain men with the necessary qualifications to carry on the work, but as soon

as they are released from war work great progress is to be expected. The field is a very extensive one; it is almost untrodden up to the present, and, no doubt, as work proceeds, it will open up new vistas for experimental investigation as all research work does. I hope that great and important results may come from this work.

Up to the present, in the manufacture of the piano, practice is far in advance of theory, and there are almost innumerable things which have been found desirable in practice for which every maker who has adopted them gives a different reason—possibly not the correct one in any case. It is these things which must be investigated. Then when we know why something needs to be done, and how a certain effect results, we may be able intelligently to improve the design and to raise the construction of the piano to a higher level. This is our hope, and if we all work together, and pool our knowledge and experience, I feel sure we can realise our ambition once more to bring back the time when Britain shall once again lead the way in the piano industry.

In addition to what I have said above on the industrial side of the pianoforte history, a great deal might be said on its æsthetic aspect. Much credit is due to those manufacturers who have been for years as "men crying in the wilderness," and who, despite lack of encouragement, have steadily persevered with their endeavours to improve the tonal value of their instruments. The developments which I have been speaking about are undoubtedly due almost entirely to their efforts. I know they have encountered a large amount of inertia, and it is only by great enthusiasm, and faith in the possibility of raising the industry to its old premier position, that they have attained the success for which all credit should be given to them. I have even heard a story that there was a time when a manufacturer being approached with the remark, "I understand you are a piano maker," replied, "You are quite wrong, my friend; I do not make pianos, I make money." I trust that any such attitude is rapidly becoming impossible, if it is not already a thing of the past.

It is a fact that must never be forgotten, that every piano produced in this country—especially if it is exported—is either helping to raise or lower the reputation of the British piano; and it is up to every manufacturer to see that he, at least, is not going to help to lower the standard; and we are very hopeful that the scheme which I have outlined may result in everyone connected with the industry, in whatever capacity, regaining the pride of craftsmanship which resulted in the foundation of the old Guilds, and that every maker, foreman, or workman, will set this high ideal before him.

There is another point. Whether it is true or not that a country gets the government it deserves, it is certain every public gets the piano it deserves; and the fact that there is a ready sale for an imperfect instrument shows clearly that a low standard of musical taste is prevalent. If we can raise the quality of the public taste, we shall ensure a larger demand for the best type of instrument.

I am glad to think that there are great hopes that the rising generation may possess a much keener appreciation of good music than their fathers. The American teachers who lately visited this country were surprised at the quality of the singing which they heard in our elementary schools. They stated that it surpassed anything they had heard in any other country, and I see that in the new Education Bill Mr. Fisher is desirous of further encouraging the teaching of music and singing in our schools. We must not be content with this. There is only one solution—there must be a combination of one and all. Musicians, composers, publishers, manufacturers, and teachers must work together, and must no longer be content to realise their own personal ambitions. For this reason I am very glad that you, Sir Frederick, have honoured me by presiding here to-day, and that I have been able to lay before you some of the difficulties and aims of the manufacturers, and I feel sure that we may confidently look to you for your co-operation. We should be most grateful to you if you would aid us by your influence and advice in bringing about a much closer co-operation and more intimate connection between the leaders and members of the musical profession in England and the productive side, who probably constitute the greater part of my audience this afternoon. Such an alliance, which I trust we may see realised in the near future, cannot fail to have great and far-reaching results, industrially, commercially, and educationally.

DISCUSSION.

THE CHAIRMAN (Sir Frederick Bridge, C.V.O., Mus.Doc.), in opening the discussion, said that he, in common with all musicians, desired to do all he could to aid in improving the musical taste and musical appreciation of this country, and to restore her former supremacy in the pianoforte industry.

With regard to the first point, people with musical taste and knowledge would not be content to put up with a poor instrument, and the increase of that taste and knowledge among the people of this country would do much to promote the production of better instruments. With reference to the second point, the Germans could not be blamed for having had the shrewdness and audacity to take possession of the British market, but he hoped that after the war everybody in the musical profession would do his utmost to see that German goods were kept out of this country, and that the supremacy of the British pianoforte industry was restored. It was true that when the "Twelve Apostles," as they were called, came to this country from Germany in 1760, they were welcomed and encouraged, and they did much to develop the pianoforte, but since then English makers, such as Wornum, Broadwood and Collard, had contributed inventions of extraordinary value, of which this country had lost the benefit. The author had mentioned that British firms had been content to retain old-fashioned actions when abroad the inventions made by Englishmen were universally used. Personally he believed that during the first three parts of the last century the pianoforte makers of this country could not be accused of such slackness, but during the last part of that century they began to lose their energy, to trust to the reputation they had already gained, and to be indifferent to the necessity of competing with the instruments that were being made abroad. The pianofortes made in this country in the early part of the nineteenth century were as good as they could possibly be. At the present time he had in his possession a little piano bought by his father when he (Sir Frederick) was a boy in the choir at Rochester Cathedral. When his father died he had the case renovated and the piano itself overhauled, and he still used it daily, and as he had been at Westminster Abbey for forty-three years, and had used the piano a great deal during all that time the instrument must have been very well made. He did not think some of the modern pianos would last so long if they were subjected to the same amount of use. With regard to the use of machinery in the manufacture of pianos, he had no doubt that the most minute perfection could be obtained in that way, and he agreed with the author that all the tools used should be sent to a central tool-house to be kept in perfect order by a man who understood the work. He thought the statement made by Dr. Lardner, and quoted in the paper, that it was impossible for a man to influence the tone of the piano by the way in which he touched the keys, could hardly be justified at the present time. He thoroughly supported the great movement of having boys apprenticed to the pianoforte business, which was a very important matter, and one in which the Musicians' Company might be able to help.

Major J. Mackenzie Rogan, M.V.O. (Bandmaster of the Coldstream Guards), said that when he went to India about forty years ago it was very difficult to get pianos of any kind there, most of those that were obtainable being old instruments of English make, whilst a few were imported from Germany. He made up his mind then that when he could afford to buy a piano it should be a British one, because when he joined the Service two-thirds of the bandmasters in the British Army were German civilians and the majority of them treated the bandsmen in the true Prussian spirit. The British musician at that time had no chance, and it was the British public that was to blame for that, just as he thought the British public was now to blame for not giving sufficient encouragement to the British pianoforte manufacturer, to the British composer, and to British music in general. The bandmaster of the regiment he joined as a boy was a very fine musician, but he was thought nothing of because he was an Englishman; whilst on the other hand a German street musician was in one case sent to an unsuspecting regiment abroad as a gem of the first water. Some years ago, when he returned to England on leave, he bought a piano from an English firm and took it back to India with him, where he had it in use for about seven years, keeping it at high pitch on the plains, where sometimes the temperature reached 110 or 112 degrees in the summer. When he left India that piano was almost as good as when he bought it, and he sold it to a dealer in India for more than the price he originally gave for it. All the pianoforte tuners that he met in India were Germans, who were out to "do the Britisher down," and he had had personal experience of a case where a German tuner had deliberately interfered with the mechanism of an English piano which he had been called in to tune. He thought that the bandmasters of the British Army could do as much as most men to advance the British pianoforte industry, because they travelled all over the world with their regiments and could give their advice to people in India, Africa, Burma, and all the other places to which they went. British officers were more disposed now to listen to the advice of bandmasters than they were thirty or forty years ago, because they realised that the British bandmasters could more than hold their own. He was glad to say that there was not a single foreign bandmaster in the British Army at the present time.

Mr. John Collard said there was no doubt that British pianoforte makers would not accept all that had been said about them at the meeting. He did not admit that they had been asleep for a number of years, but thought that for a long time they had made the very best and most reliable instruments that could be manufactured, although it was quite true that they did not always adopt the changes that were introduced on the Continent. He himself had been actively associated with the industry for fifty years, and during the whole of that time his firm had done all they could to turn out good work in as large a quantity as possible, and he

believed that was true of all the other pianoforte manufacturers in this country who had a reputation to sustain. At one time they were very seriously handicapped by German competition, but during all that time there was thoroughly good and reliable work being done amongst British manufacturers. If people would not be so willing to take goods that came from abroad, but would stand by British goods, they would find that British pianoforte manufacturers would supply them with instruments that would be a credit to them as makers and advantageous to the public who purchased them.

MR. JOHN D. CHALLEN supported Mr. Collard in denying that British pianoforte manufacturers had been wanting in energy during the period, say, from 1880 to 1900. In the year 1885 his firm sent to the Melbourne Exhibition up-to-date pianofortes built with iron frames and over-strung, and they received the highest number of points on the jury list for those instruments. At that time his firm was sending thirty pianos a month to Melbourne, and one would have thought that their success at the Melbourne Exhibition would have sustained and improved their reputation; but from that date their trade decreased to zero, owing to German competition. The German manufacturers sent over a very large number of instruments in ships subsidised by the German Government, the manufacturers themselves being assisted by banking facilities, and those pianos were dumped upon the market and offered to dealers in large quantities. The dealers had to buy them to protect themselves, because when they refused the Germans threatened to put the pianos into the auction room, with the result that the market would be flooded with them. Those German methods of penetration accounted in a great measure for the British manufacturers having lost their hold on the Colonial markets. The same thing had happened in this country also, but we had learned our lesson now. If measures were taken to strengthen the home market, and to establish the industry on a firm foundation, British pianoforte manufacturers had the ability and the enterprise to enable them to hold their own in a fair field. He very much valued the establishment of the Research Department, of which the author was the distinguished head. It marked an era in the history of the pianoforte industry that now a trained scientist had come forward to inquire into matters which the practical man in the workshop was incapable of investigating. The author was looking at the manufacturing side of the industry on the one hand and at the distributing side on the other, and on the distributing side he looked forward to getting the support of the musical man. There was no doubt that that support ought to be obtained. Before the war musicians favoured German instruments, but he did not think they would do so in the future, and British manufacturers ought to do all they could to produce the best possible instruments.

MR. JAMES A. MURDOCH (President of the Pianoforte Manufacturers' Association) said he thought too much had been heard at the meeting about the past, and too little about the future. It was important for the British pianoforte manufacturers to gain the support of the musical profession, and he was pleased to see present two distinguished members of that profession—the Chairman and Major Rogan. He agreed with the latter as to the influence of the British Army bandmasters who went to all parts of the world, and was interested to hear of Major Rogan's experiences in India, from which country he had recently received a very interesting and gratifying report. He thought the British industry could look forward hopefully to the future, and a meeting such as the present one gave the Pianoforte Manufacturers' Association every encouragement to go on with the programme they had already outlined.

On the proposition of the CHAIRMAN, seconded by Mr. T. DYSON, a hearty vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

ENGINEERING NOTES.

The Centenary of the Institution of Civil Engineers.—A milestone in the history of the profession has been marked by the centenary celebration on January 2nd last. The avocation is commonly, but mistakenly, called civil in contradistinction to various other callings, such as mechanical, marine, mining, electrical, gas or other similar occupations. The charter does not recognise these distinctions, and excepts only the term military engineers from the list of the corporate members of that body, and, moreover, the history of the proceedings amply justifies that exclusion. It is remarkable that in the charter of the Institution which describes the profession, that of the railway engineer is not included. A trial by locomotives on rails by Trevethick was made in 1808, nine years before the date of the charter, and the first public railway was opened seven years later. But the first beginnings of the locomotive were made about sixty years earlier, and many experiments were made in the course of the eighteenth century. Surely the promoters of the Institution were strangely cautious to object to the introduction of the steam locomotive, which to-day is universal over the continents of the world.

By-product Coking.—Mr. G. B. Walker, in his recent paper before the Institution of Civil Engineers, points out that the war having stimulated the demand for hydrocarbon explosives, these are now commandeered by the Government, the coking plant necessary for recovery of the explosives being under the control of the Ministry of Munitions. Although the principle of external heating of the retort oven, as originally introduced by Evence Coppée, remains the same, considerable

modifications in detail have been gradually introduced by various builders as the result of experience. The object of these modifications has been chiefly to increase the rapidity of the coking process by the application of more intense heat, and by the heating of the air for combustion; convenience and economy in operation have also received much attention. The recovery of by-products has been greatly developed, and in particular many experiments, with more or less success, have been made for achieving the "direct" recovery of sulphate of ammonia. One of the most important developments has been the utilisation of the surplus gases in internal engines, and for town illumination, metallurgical furnaces, and other manufacturing purposes. Mr. Walker describes the principal features of half a dozen of the most successful types of oven in use in this country, and the recovery plants associated with them, and cited figures showing the economics obtained by the "direct" recovery of sulphate of ammonia, here and in Germany. He also compares the relative value of the surplus gases used in producing steam (utilised through turbines) and in internal-combustion engines, to the advantage of the latter.

Concrete Shipbuilding.—We have referred to this subject in our number of October 12th last, and revert to it in the following extract from *Concrete*. The first British-built concrete motor launch has now taken the water. This vessel has dimensions 23 ft. by 5 ft. 3 in., by 14 in. draught, and is of the fast estuary type. The method of construction has been a special one, the concrete shell being only $\frac{5}{8}$ in. thick. Of a larger character is a motor coaster 92 ft. 4 in. by 19 ft. by 19 ft. by 10 ft. draught, a boat about to be laid down in a British yard, which will have a motor winch, the usual raised quarter-deck and forecastle, a large hold, hatchway, and engine aft. America is going one better than this by building a concrete ocean-going vessel about 300 ft. long, with a cargo capacity of 4,500 tons. The shell of the hull is 6 in. thick, and will weigh less than a wooden hull for the same cargo capacity. Only ninety days will be required to build the first vessel of the type; soon it is expected to build the hulls in two months, or in even less than that time. Reinforced concrete has several advantages over the steel and wood hulls, one being durability, as apparently, provided that the vessel is well designed and carefully constructed, the greater the age the stronger she gets; in fact, at about twenty years' old she should be in very much better condition, so far as strength and tightness are concerned, than a new vessel built of steel, or the famous old iron hulls.

British Engineering Extension in China.—Mr. A. Rose, C.I.E., H.M. Commercial Attaché at Shanghai, delivered a lecture lately to the London Chamber of Commerce on "The Prospects of British Extension in China." He said that there can be no doubt that China offers a wonderful field for many forms of engineering enterprise, for textile machinery in the cotton-growing districts, for electric light and power plants, for pumps, motors, and all the machinery and accessories which are essential to industrial enterprise both on land and on the water. At present there are only 87 electrical installations in operation in China. The Germans secured a large number of these contracts in consequence of their co-operative system, which enabled one central institution to quote for and supply complete installations, and, if necessary, to finance them. He had never made a journey into the interior without receiving constant inquiries for machinery of all sorts, but the Chinese know little of the scope and possibilities of mechanical power. They need careful education as to the machinery which can be useful to them, as to where they can obtain it, what it will cost, what profit it will make, and how they can manage to pay for it. Such information can only be supplied by men who are especially trained for the work, and who can devote their whole time to it. Our young practical engineers seem to have the knack of winning the confidence of the Chinese, and all that we need is more men of that type in the field.

Victorian Coal.—In a recent speech, Mr. Livingstone, Minister of Mines, Victoria, is reported to have said that in the very near future the brown coal industry would be one of the greatest in Victoria. When the deposit at Morwell was properly opened up this State would be independent of Wonthaggi and Newcastle. Besides the coal in the open cut, it was estimated that 100 ft. below there were 13,000,000 tons of coal. He was waiting for the reports of electrical engineers, and if they were what he expected, the Government would be recommended to transmit power from Morwell, which would run nearly all the machinery in Melbourne, and at a cheaper rate than water could produce it.

Indian Superheater Locomotives.—The results obtained with superheater engines in India fully justify the decision come to by many railway administrations that all engines for main line work should be fitted with superheaters. The last Indian Railway Board report gives an instance of a superheater engine (2–8–0 type) which was tried for several months on the heavy grades (1 in 25) between Sibi and Quetta on the North-Western Railway, with most satisfactory results, showing a saving in fuel of nearly 30 per cent., as compared with saturated engines of the same class, and handling the same loads with much greater ease. The use of superheater engines is also extending to 2 ft. 6 in. gauge lines, which were supplied by the North British Locomotive Company and are equipped with the Robinson superheater.

GENERAL NOTE.

THE RARER MINERALS IN THE BRITISH EMPIRE.—In a lecture before the London School of Economics on November 16th, 1917, Mr. Sydney Johnstone, of the Scientific and Technical Research Department of the Imperial Institute, pointed out that almost all the rarer key-metals can be obtained within the British Empire. Tungsten is obtainable from Burma (now the most important producing centre in the world), Queensland and elsewhere, and the Empire provides 35 per cent. of the world production. The metal is also now being extracted successfully in the United Kingdom. Molybdenum is another metal which the Empire produces in adequate supply. Both are of great value for special armament steels and for high-speed tools. The monazite deposits in Travancore and Ceylon are the richest in thoria known, and contain abundant supplies of ceria, the other chief rare earth required for incandescent mantles. Ferrocerium, an alloy of iron and cerium, has useful applications for pyrophoric automatic lighters, and has been employed for tracing the flight of shells. Practically the only valuable key-metal which the Empire can only produce at present in very small quantities is platinum. It was suggested, however, that much larger quantities of this might be obtained in certain metallurgical workings in Canada, from which platinum, palladium and other rare metals could be derived as a by-product.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

JANUARY 23. — ALEXANDER NEWLANDS, M.Inst.C.E., Chief Engineer, Highland Railway, "Water Power in Great Britain (with special reference to Scotland): its Amount and Economic Value." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

JANUARY 30.—SIR WILLIAM GEORGE WATSON, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." SIR ARTHUR D. STEEL-MAITLAND, Bt., M.P., will preside.

FEBRUARY 6.—WM. FRECHEVILLE, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of Mineral Resources of the Empire." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

FEBRUARY 13.—LORD LEVERHULME, "The Relations between Capital and Labour — Reasonable Hours, Co-partnership, and Efficiency." W. A. APPLETON, C.B.E., Secretary of the General Federation of Trade Unions, will preside.

FEBRUARY 20.—MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." SIR ASTON WEBB, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

FEBRUARY 27.—SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

MARCH 6. — A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

MARCH 20. — FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

Dates to be hereafter announced :—

MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War."

MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. LAWRENCE BALL, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

FEBRUARY 14. — SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India." The RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

MARCH 14.—

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India."

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Colonial Section.

Tuesday afternoons, at 4.30 p.m.:—

February 5.—C. du Plessis Chiappini, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

March 5.—

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

Cantor Lectures.

Monday afternoons, at 4.30 p.m. (unless otherwise announced):—

Charles R. Darling, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." Three Lectures.

Syllabus.

Lecture I.—January 21.—*Methods of Producing High Temperatures.* Special fuel furnaces—Oxy-hydrogen flame—Oxy-acetylene—Thermit—Electric furnaces.

Lecture II.—January 28.—*High Temperature Processes.* Smelting of platinum and metals of high melting-points—Welding and cutting by oxy-acetylene flame and electric arc—Thermit welding—Production of steel and other metals by electric furnaces—Fixation of atmospheric nitrogen—Metal spraying.

Lecture III.—February 4.—*Products and their Uses.* Artificial graphite for various purposes—Carborundum for abrasion and refractory purposes—Alundum and silica for chemical apparatus and refractories—Calcium carbide for making acetylene—Pure metals by thermit processes—Siloxicon and other silicon—Carbon compounds for refractories and thermal insulators—Aloxite and its uses.

Edgar Crammond, Secretary of the Liverpool Stock Exchange, "The Economic Condition of the United Kingdom before the War: The Real Cost of the War: and Economic Reconstruction." Three Lectures.

February 18, 25, March 4.

J. Young, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

Cobb Lectures.

Professor Henry R. Procter, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

Monday, January 21...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. C. R. Darling, "High Temperature Processes and Products." (Lecture I.)

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Rev. Canon J. O. Hannay, "The Church and the Army." (Part II.)

Geographical Society, Kensington Gore, S.W., 5 p.m. Mr. W. J. Harding King, "Study of a Dune Belt."

Engineers, Cleveland Institute of, Corporation-road, Middlesbrough, 7.30 p.m.

Tuesday, January 22...Engineers, Junior Institution of, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Mr. F. W. Lanchester, "Industrial Economics, during and after the War."

Royal Institution, Albemarle-street, W., 3 p.m. Professor W. M. Flinders Petrie, "Palestine and Mesopotamia." (Lecture II.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Mr. F. Reeves, "Rail-Creep." 2. Mr. H. P. Miles, "Creep of Rails."

Wednesday, January 23...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. A. Newlands, "Water Power in Great Britain (with special reference to Scotland): its Amount and Economic Value."

Geological Society, Burlington House, W., 5.30 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor E. W. Hope, "Some Constructive Suggestions in regard to the proposed Ministry of Health."

Colonial Institute, Caxton Hall, Westminster, S.W., 4 p.m.

Japan Society, 20, Hanover-square, W., 3.30 p.m. Mr. T. Khori, "Japanese Drama."

Thursday, January 24...Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor S. Wilkinson, "Generalship—a Campaign of Napoleon's (1808)." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Major D. C. Campbell, "Flying and Photography."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. F. G. C. Baldwin, "Telephone Exchange Transfers and their Organisation."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. F. A. W. Phillips, "British Trade and the Metric System."

China Society, School of Oriental Studies, Finsbury-circus, E.C., 3.30 p.m. Mr. M. F. A. Fraser, "Annals and Anecdotes of Jengiz Khan."

Friday, January 25...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor J. S. Townsend, "The Motion of Electrons in Gases."

University of London, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture II.)

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Saturday, January 26... Royal Institution, Albemarle-street, W., 3 p.m. Professor W. J. Pope, "The Chemical Action of Light." (Lecture II.)

Offer of a Set of Journals.—A set of unbound *Journals*, in good condition, extending from 1902 to 1909, and from 1910 to 1915, has been placed at the disposal of the Secretary of the Royal Society of Arts for presentation to a public library or institution which will undertake to bind and preserve them. The Society is willing to add a bound volume for 1909–10. Applications should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2)

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FRIDAY, JANUARY 25, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 28th, at 4.30 p.m. (Cantor Lecture.) CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." (Lecture II.)

A demonstration of oxy-acetylene welding and cutting will be given.

WEDNESDAY, JANUARY 30th, at 4.30 p.m. (Ordinary Meeting.) SIR WILLIAM GEORGE WATSON, Bt., Chairman of the Maypole Dairy Company, "The Manufacture of Margarine in Great Britain." SIR ARTHUR D. STEEL-MAITLAND, Bt., M.P., will preside.

Further particulars of the Society's meetings were published in the last issue of the *Journal*.

CANTOR LECTURE.

On Monday afternoon, January 21st, Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, delivered the first lecture of his course on "High Temperature Processes and Products."

The lectures will be published in the *Journal* during the summer recess.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO MR. ORVILLE WRIGHT.

A report has just been received of the ceremony held at Memorial Hall, Dayton, Ohio, on October 27th, when Lord Northcliffe presented the Society's Albert Medal to Mr. Orville Wright. Dayton is the birthplace and home of the Wright family; it was here that the brothers Wright conducted their principal experiments in aviation, and it is now a large and rapidly-growing centre of aeroplane manufacture.

Lord Northcliffe said that when he heard from His Royal Highness the Duke of Connaught that it was the desire of the Royal Society of Arts to award their Albert Medal to Mr. Orville Wright, he eagerly accepted the suggestion of the British Ambassador at Washington that he should proceed to Dayton and make the presentation. Wilbur and Orville Wright were the first persons to ascend from earth in a mechanically-propelled airplane. To them, and to them only, was due the credit. Moreover, they were the real inventors of the means of controlling all airplanes.

What the two brothers had done for aviation was generally being realised throughout the world. Without aviation it would at the outset have been impossible for the British to defend themselves on their line in France and Flanders against the great guns which the Germans had been preparing for forty years. By means of this invention they were able to locate those guns and put them out of action. The British nation was therefore grateful to the Wrights for enabling them to be provided with a machine that carried them over the period when they were building their great guns.

That the Germans should have misused this machine, that they should delight in dropping bombs upon the poorer parts of our great cities, and on our seaside resorts, and that they should take pleasure in killing women and children, was not the fault of the inventors of this machine, for the Germans turned every scientific invention to the purpose of war. As for ourselves, we regarded the invention of the Wrights as the means of protection of our island against possible future wars. We believed that the airplane would enable us, with our comparatively small population, to defend ourselves against any future combination of the Central Powers of Europe. Lord Northcliffe also expressed the belief that the work going on at Dayton to-day, the work which he had seen that morning, would help to bring this horrible war to a conclusion.

PROCEEDINGS OF THE SOCIETY.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 23rd, 1918; SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., Member of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Balston, Reginald M., London.
Beamish, Richard H., D.L., Cork, Ireland.
Beckett, Joseph Edge, London.
Dawson, Charles Williamson, London.
Dewar, James M., London.
Dyson, Sir Charles Frederick, J.P., Windsor.
Jack, Henry Joseph, North Wales.
Livingstone-Learmonth, Thomas Livingstone, London.
Love, Charles William Grosse, London.
McKnight, William Archibald, Chile, South America.
Miller, Hans Eric, London.
Sowrey, Major John, R.F.C., Newmarket.
Woodward, William Harrison, Farnham, Surrey.

The following candidates were balloted for and duly elected Fellows of the Society:—

Anderson, Gilbert, London.
Attwater, Richard, Preston.
Baroda State, The Minister of Education, Baroda, India.
Boote, Edgar M., Coventry.
Bradshaw, Granville E., Walton-on-Thames.
Chadwick, David Thomas, I.C.S., Beckenham, Kent.
Coatalen, Louis, Wolverhampton.
Diamant, A. St. John, L.R.I.B.A., Egypt.
Forster, Martin O., D.Sc., Ph.D., F.R.S., London.
Lo Tian Cheok, The Hon., British North Borneo.
Mastin, John, D.Sc., Litt.D., Kenyon.
Mort, George Frederick, London.
Pegler, Frank, Retford.
Sempill, Wing-Commander the Master of, R.N.A.S., London.
Ware, Alfred George, Bournemouth.
Willis, Thomas Wilkinson, Sheffield.

The paper read was—

WATER POWER IN GREAT BRITAIN (WITH SPECIAL REFERENCE TO SCOTLAND): ITS AMOUNT AND ECONOMIC VALUE.

By ALEXANDER NEWLANDS, M.Inst.C.E.,
Engineer-in-Chief, Highland Railway.

The situation created by the war has immensely intensified our interest in all questions affecting our social and economic existence, which it is sometimes said we shall have to construct anew on the conclusion of peace. This belief, at the present time, finds expression in the general trend of public opinion towards a desire for investigation and research. It may be said that waste in any form is now abhorred, and that economy has become our watchword. In particular, the former waste and abuse of our natural resources is being keenly inquired into, and evidence of this is found in the important and far-reaching proposals towards national reconstruction which are contained in the Report of the Coal Conservation Sub-Committee of the Ministry of Reconstruction.

The legislative aspect of the problem considered by the Sub-Committee is being investigated by a Committee appointed by the Board of Trade, the end in view being to "ensure that there shall be an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly industries which depend upon a cheap supply of power for their development."

The Sub-Committee proposes to supply all industries with electrical power generated at big super-power stations, not more than sixteen in number for the whole country, and to eliminate or combine all smaller stations. The primary object of the scheme is to economise our coal supplies by a national scheme of electrification. Fifty-five million tons of coal out of 80,000,000 used in the United Kingdom for the production of coal could be saved. This, with the saving of by-products now wasted, would effect a saving of millions of pounds. An increase in the use of power is of the highest importance to the future prosperity of the country.

The development of electricity has been hindered by the excessive number and smallness of electrical undertakings. At present the supply of electricity in Great Britain is split up among six hundred companies and municipal undertakings. The reform proposed by the Committee is to supersede small undertakings by laying down throughout Great Britain a network of trunk lines to be fed by these sixteen "super-power stations." Generating machinery should be of 20,000 h.p., and in important industrial districts of 50,000 h.p. By-products might be extracted from coal before it is used for the production of power, and various electro-chemical processes which are essential for this country should be carried on near by. Sites for stations must be outside towns. The power authorities will be controlled by a National Board of Electricity Commissioners. Existing plants will be handed over on equitable terms to the new authority.

The value and importance of such an investi-

gation cannot be doubted, and, as bearing upon the subject, it is interesting to read the report of Mr. Wilson Fox, M.P., Hon. Secretary of the Empire Resources Development Committee, at a recent meeting at the Aldwych Club, when he said that by centralisation of power supply, and the careful conservation of by-products, as well as by the sale of power, a saving to the State of £100,000,000 per annum could be effected. This would represent a reduction of 2*s.* 6*d.* per £1 in the income tax. It should be noted that centralisation of power supply, with proper transmission, is the negation of centralisation of industry.

Coal has ever been, and will probably continue to be, our principal source of power, but in considering the question of power it is sometimes forgotten that one cubic foot of water per second falling eleven feet will give one horse-power in any modern turbine, and no investigation into the power resources of the country is complete that does not include water power within its scope.

The continued non-utilisation of the water power of these islands is an economic waste. In the census of production report for 1907 we find that the total power of industrial engines in Great Britain and Ireland is 10,578,485 h.p.; road rollers and road locomotives owned by public authorities, 167,192 h.p. Of these industrial engines, steam reciprocating engines represent 9,118,818 h.p.; steam turbines, 530,892 h.p.; internal-combustion engines, oil, gas, etc., 680,177 h.p.; and water power, 177,907 h.p., or 1·6 per cent. of the total. It is computed that 2,500,000 h.p. is employed in the production of electrical energy.

General Considerations.

In considering to what extent water power could contribute to our total power requirements, several important considerations have to be kept in view. For instance, when we draw from our coal supply for power we are drawing from a source which is not inexhaustible. The late Sir William Ramsay estimated that, at the wasteful rate at which we were using up our coal supplies in 1911, we might look for their complete exhaustion in a period which he estimated at 175 years, and long ere that time coal would be scarce and dear. In 1907 we raised 6 tons of coal per head of population as against 3½ tons in Belgium, and 2½ tons in Germany. It is much to be desired, therefore, that the aspirations of the Sub-Committee should speedily materialise. Sir Dugald Clerk considers that our fuel needs could possibly be met by the economical use of one-half of the coal we now use, and advocates a more extended use of water power.

Atmospheric precipitation in the form of rain or snow is the source of all our supply of water. This rainfall gravitates into lakes, rivers, and subsoil areas, according to the physical and geological character of the country on which it falls, and it is chiefly by the impounding and control of it that it can be utilised for power production.

It is, however, sometimes forgotten by enthusiasts on the subject of water power that all rainfall cannot be set aside for their requirements. Rainfall is primarily required for domestic water-supply. Industrial and manufacturing interests, as well as supply for canals and for navigation and fishing in certain of our rivers, must be provided for, as must also agriculture. Agriculture is peculiarly dependent upon surface rainfall in proper season, but over and above the surface supply it is estimated, in the "Water Powers of Canada," that in the upper 100 ft. of the earth's surface there is stored sufficient water to form a lake 17 ft. deep, or a total equal to about seven years' rainfall. In times of drought this underground storage is drawn upon to some extent, and chiefly by capillary action by the plant life on the surface.

We may infer, therefore, that in pervious areas the unrestricted abstraction of subsoil water by pumping or deep drainage may have as injurious an effect on agriculture as would the diversion of the surface rainfall for power purposes.

Meteorologists are practically agreed that continuous records for about thirty years are desirable in arriving at reliable figures of "average" rainfall in any country. For the thirty years, 1870–1899, Dr. Mill has worked out the following average figures for the British Isles:—

	Area.	Average Rainfall.
	Square miles	Inches.
England	50,053	31·62 say 32
Wales	7,376	49·53 „ 50
Isle of Man . .	224	34·66 „ 36
Scotland . . .	27,413	46·85 „ 47
Ireland	32,694	42·28 „ 42

or an average for the British Isles of 39 in.

It will be recognised that without a close scrutiny into the distribution of this rainfall, "average" figures for a country as a whole cannot be made much use of by investigators of water power possibilities, but, fortunately, Dr. Mill goes minutely into this question of distribution. All rainfall, therefore, cannot be utilised for power, and the question of the amount of it which can be so used is a very complex one.

Rivers.

In many countries the natural flow of great rivers is available for vast power possibilities. Comparatively few of our largest British rivers are, however, so reliable and uniform in their daily discharge as to render even a reasonable proportion of the total rainfall they deal with available for power.

Moreover, it is chiefly in the relatively short length of their upper reaches that the largest English rivers have any considerable fall. Except near their source many of them have a fall of not more than one or two feet per mile, and are tidal and navigable for long distances inland. On the other hand, there are large rivers, such as the Dee, Spey, Findhorn, Conon, in regions like the Scottish Highlands, which have a fall of fourteen and sixteen feet per mile near their mouths, and on many smaller ones the fall is very much greater. An excellent feature of several of the great Irish rivers is that they have a very considerable fall almost at the point where they discharge into the sea.

River discharge, as affected by rainfall, is primarily dependent upon the slope or inclination of the catchment area, although the geological character of the area, the average temperature, the presence or absence of agriculture and afforestation, enter into the question. The following examples, from Stevenson's "Canal and River Engineering," illustrate the variation n flow which exists in rivers in different parts of the country, and the hopelessness of arriving at any accurate general deductions from them:—

	Surface slope inches per mile.	Cub. ft. per min. per square mile.
Boyne	—	257
Clyde	$1\frac{1}{3}$	65
Conon	(Rapid River)	19·9
Forth	11	75·7
Foyle	$1\frac{1}{4}$	28·6
Ribble (before works)	47·8	159
Tay (before works)	2 to 9	120
Wear	16	22
Thames	1 to 20	20·4

The rainfall in the catchment areas is not given. In arriving at general conclusions for purposes of power investigation, what detracts from the value of these figures, apart from the want of uniformity in them, is that they are evidently deduced from gaugings taken near the mouths of the rivers. The discharge per square mile given practically represents, therefore, the total discharge divided by the entire drainage area, much of which is subject to a low rainfall, and is open, flat, permeable country.

Beardmore's Hydraulic Tables give ordinary summer discharges of various rivers, streams and springs, as uninfluenced by any immediate rains. The geological formation of the catchment areas is also given. The results vary in an extraordinary manner—viz., from 2·4 cubic ft. per minute per square mile in a chalk area to 400 cubic ft. per minute per square mile, this latter being the winter discharge off a felspar formation.

It will be seen, therefore, that river discharges vary within a very wide range, but it may be presumed that, speaking in general terms, short rivers with a rapid fall give a much less ordinary discharge than long sluggish rivers, the obvious reason being that the rapid river runs off its heavy rainfall in floods. Moreover, the catchment areas drained by these rapid rivers are, as a general rule, of a mountainous, bare, and impervious character, where little percolation or saturation can take place.

It is interesting in this connection to note that it is already becoming observable in the Scottish Highlands that the rapid deforestation of the country for national purposes is having the effect of increasing the number of floods and the volume of flood discharge in that part of the country. The cutting of shallow open drains for improving the hill pasturage for sheep grazing was previously observed to have had the same effect.

In "Canal and River Engineering" the following ratios of ordinary to flood discharge are given:—

Thames	1 to	5·9
Erin	1 ,,	3·9
Clyde	1 ,,	4
Tay	1 ,,	3·4
Conon	1 ,,	27·2
Ganges	1 ,,	2·4
Irrawaddy	1 ,,	10
Mississippi	1 ,,	1·9
Nile	1 ,,	9·5

The figures are given with reserve, and, I think, rightly so, as especially for short, rapid

rivers the difference between low summer flow and maximum autumn flood is greater than that given.

The following figures regarding the River Ness, abstracted from a report by the late Mr. Bateman in 1870, are of value, as they deal with the characteristics of a river draining one of the wettest and most mountainous regions in the British Isles. The Ness is only seven miles in length. It flows out of Loch Ness, which has a drainage area of 683·3 square miles, an area of 13,940 acres, or 21·8 square miles, and is twenty-four miles long by an average of one mile wide. Its elevation is 50 ft. above Ordnance Datum. A very large loch such as this almost certainly acts as a regulator, and has a considerable effect upon the river discharge. Mr. Bateman estimated the ordinary flow of the river at 250 cubic ft. per second, and the flood discharge during two memorable floods in 1834 and 1849 at 29,000 and 52,000 cubic ft. per second respectively, the ratio of ordinary to flood discharge being for the 1834 flood 1 to 116, and for the 1849 flood 1 to 208. The same ratio for the Conon, already noted, is 1 to 27·2, and the ordinary flow of these rivers works out at 20 cubic ft. per minute per square mile in the case of the Conon, and 22 cubic ft. in the case of the Ness. From the "Investigation of Rivers" report it would appear that the summer flow of the Severn—a typical large English river —is about 28 cubic ft. That of the Derwent is 11·1 cubic ft., the flow in winter flood being 452 times greater.

Twenty cubic ft. per minute per square mile is probably a rough approximation of the summer flow of our short rapid rivers.

All the foregoing figures must be received with caution. There is much valuable evidence on the subject on record, and much good work is daily being done, but there is such a want of uniformity in the matter of units used in recording results that the whole subject becomes somewhat bewildering. For instance, "ordinary" flow is too indefinite to corelate with either "minimum or "average" flow, although in perusing the text in various authorities one is led to think they are intended to mean the same thing. "Flood discharge" is too indefinite, as floods vary within a wide range. It is much to be desired that the flow of rivers and yield of catchment areas could all be put on record in definite standard units.

The investigation of the water power possibilities of any particular area involves a very large amount of study and labour, and, unfortunately, the results arrived at may be practically valueless if applied even to an adjoining area.

Each catchment area is a problem in itself, and it is extremely difficult to generalise upon the power possibilities of a whole country even with approximate accuracy.

SCOTLAND.

Power by Impounding.

Scotland, and in particular the Scottish Highlands, being the country north of the Forth and Clyde, possesses more water power possibilities than any other part of Great Britain This part of Scotland is the most extensive mountainous region in the British Isles, and it has within it, as a whole, the highest rainfall. the only localities comparable with it as regards rainfall being Seathwaite in Cumberland and Snowdon in Wales. An annual rainfall of 160 in. has been recorded on Ben Nevis; 182 in. in Cumberland: and 193 in. on Snowdon.

Over a considerable extent of this northern area of Scotland the rainfall exceeds 60 in. per annum. and it is fairly uniform throughout the year. On the west coast particularly the climate is humid and moist, and there is comparatively little loss due to evaporation, and geologically the area belongs to the older primitive rock formations, so that little percolation takes place. The country is, however, bare, largely uncultivated and treeless, so that much of the rainfall is meantime lost in flooding in the rivers.

From the water power standpoint, the fine, natural lochs, many of them of large area, and at very considerable elevation, are of extreme value. They act as regulators to the rivers in dealing with the discharge of abnormal rainfall, and, in many cases, are ready to hand for regulation and control as power dams. The Highland area under review extends to, approximately, 12,000 square miles, and the seaboard surrounding it is extremely indented and extraordinarily developed, long sea lochs running far inland, affording excellent facilities and shelter for shipping. No part of it is more than twenty miles from the sea or the Caledonian Canal.

There is no melting of snow throughout the summer months to augment the natural flow of the rivers, as in Switzerland, Norway, and Sweden; but, on the other hand, the fine equable climate renders interruption of power plants by snow and ice in the winter improbable.

It is in a country such as this that one looks for possibilities of power in bulk.

Generally speaking, the highest land has the

highest rainfall, and the Scottish Highlands is the largest and most uniform tract of country approaching and exceeding 3,000 ft. in height to be found in Great Britain. Calculating from Bacon's Map of Average Rainfall, prepared by Dr. Mill, I find that there is in Scotland, and chiefly in the Scottish Highlands, 11,500 square miles of country, or 42 per cent. of the total area, having a rainfall of 50 in. and over.

The following table admits of comparison with the rest of Great Britain :—

estimate of the water power available in Scotland by the impounding of the discharge from the loch basins. For this purpose I have assumed an average rainfall of 42 in. This as an average rainfall is, of course, exceeded over more than half the area of Scotland. Moreover, the records of rainfall are obtained from gauges that, as a rule, are situated at lower levels rather than at the higher elevations where rainfall is greatest. In any case it is usually impossible to impound all the rainfall which would flow to the sea ; and,

AREAS HAVING 50 INCHES OF RAINFALL AND OVER.

	Total Area.	50-inch area.	Percentage of Total Area.	Location.
	Square miles.	Square miles.		
Scotland	27,413	11,575	42 per cent.	Scottish Highlands and Southern Uplands.
England	50,053	3,360	6·7 ,,	Lake and Shap Districts and Devon & Cornwall.
Wales	7,376	3,390	46 ,,	Entire Central area.
Ireland	32,694	5,910	18 ,,	Chiefly Donegal, Connemara, Killarney.

It may be noted that in the Scottish Highlands the 40-in. average rainfall line scarcely gets east of the Highland Railway, notwithstanding that the great Grampian range of mountains is situated there. The explanation is that the rain clouds blowing in from the Atlantic discharge their rain on striking the mountainous region to the west of the Grampians.

The Bathymetrical Survey of the Scottish Fresh Water Lochs is of the greatest assistance to anyone interested in the water power possibilities of Scotland. I venture to say that this great work of Sir John Murray and Mr. Lawrence Pullar will yet be appreciated as it deserves to be. Nothing of the same kind has been done for the rest of Great Britain so far as I can learn, except the similar and equally valuable work by Dr. Mill for the English Lake District, and that by Professor Jehu for Wales.

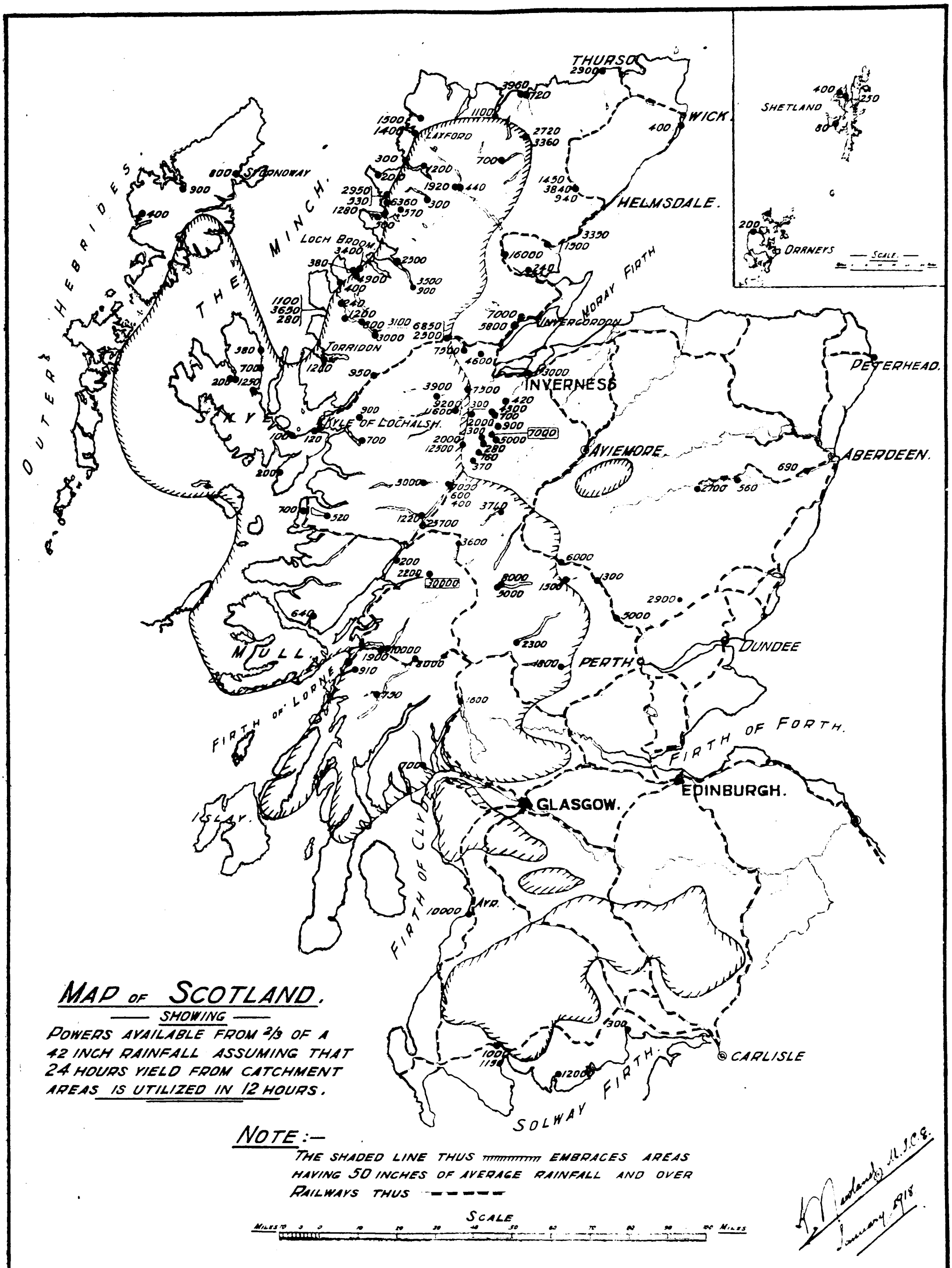
It is much to be desired that a bathymetric survey of the inland waters of the remainder of Great Britain should be put in hand, and in view of the importance and value of such a survey it should be undertaken either by the Ordnance Survey Department or the Hydrographic Department of the Admiralty, and not be left to the zeal and public spirit of private individuals.

With the information available in the Bathymetrical Survey, and the use of contoured maps, I have endeavoured to arrive at an approximate further, it is desirable to arrive at figures which will understate rather than exaggerate the ultimate power possibilities. A final reason for adopting a 42-in. rainfall is that, if uniformly discharged, it represents a yield from catchment areas of 3 cubic ft. a second per square mile, and this is a very convenient figure for approximate calculation.

Drainage areas have been taken from the Bathymetrical Survey referred to. In every case a loch has been selected for regulation and control as an intake, and the drainage area of it taken as the catchment available, although manifestly in the case of a long open conduit, leading to a pressure pipe, additional water could be intercepted.

The fall available has been reckoned as that from the intake to the nearest point on the seaboard, or on the route of the Caledonian Canal, or nearest line of railway, these being the localities where industrial works would most readily be laid down.

Of the 42-in. rainfall it is assumed that two-thirds, or 28 in., is available for power, and the figures on the accompanying map represent the power available, assuming that the flow for twenty-four hours is utilised in twelve hours, the efficiency of the machinery being reckoned at 75 per cent. It will be noted that 14 in. of the assumed 42 in. have been deducted. This, and any surplus over 42 in., is therefore reserved



for evaporation and absorption, and for compensation to rivers.

If, as previously suggested, the summer flow of rivers in mountainous districts be 20 cubic ft. per minute per square mile, equal to $4\frac{1}{2}$ in. of rainfall, a total of 14 in. would maintain three times the summer flow in these rivers, but evaporation and absorption would have to be met by the rainfall in excess of 42 in.

It may be argued that evaporation and absorption are not sufficiently provided for, and probably this is so, but it may be assumed that

some part of the rainfall lost by absorption is eventually recovered; and as regards evaporation this is not excessive in regions such as we are considering, where the rainfall is fairly regular and the climate moist and humid. The usual allowance for evaporation—12 in. to 16 in. of rainfall per annum—may, therefore, be excessive in this case. As regards compensation to rivers, from one-quarter to one-third of the total rainfall is considered liberal. In Scotland the latter figure has almost become standard, it having been awarded by arbitration to the River Tweed—a famous salmon river—from the Talla drainage area when it was impounded for the supply of domestic water to Edinburgh.

If our previous deductions as to the ordinary flow of rivers be correct, such an amount of compensation water would maintain about three times the summer flow in a river, but abnormal flooding would be checked, and while floods at inopportune times destroy spawning beds they, on the other hand, have a cleansing effect on the alveus of a river, and it is for salmon-fishers to say whether their general effect is for good or evil.

Along with the map, I have given, in an appendix at the end of this paper, the data from which the powers have been calculated. It must be distinctly understood, however, that the map, the data referred to, and the method of calculating the powers, are simply an attempt to deal in a general manner with the possibilities of water power existing in the country and to arrive at an approximate estimate of the amount of such powers. For instance, it may be that certain of the powers given must be rejected on the score of expense in development. On the other hand, no allowance has been made in the estimate for possible additions to the drainage areas of the lochs by diversion and collecting works, nor for any special storage such as would give increased powers for, say, 100-day periods, as well as increased head.

The powers on the map total up to 375,000 h.p. in round figures. By diversion and linking-up of adjoining catchment areas, and by impounding beyond the extent provided for in preparing the estimate, it may be assumed that, for, say, 100 days' supply, 650,000 h.p. is available. This is based on what has been done at Kinlochleven. By our formula the power from the 55 square miles of drainage area would be 17,500 h.p., whereas we are told that it is equal to 30,000 h.p. for 100 days.

The Clyde, Forth, and Tweed basins have not been dealt with, owing to the important water-supply and other interests already involved nor have the power possibilities of rivers and small streams been included.

The over-all cost of development per horse-power cannot manifestly be generalised upon.

Existing and Other Attractive Powers.

In the Scottish Highlands the largest installations so far laid down is the Kinlochleven works of the British Aluminium Company.

The drainage area is the relatively small one of 55 square miles, but it has no natural reservoir within it, so that the expense of constructing a dam of a maximum height of 86 ft. and of a length of 1,037 yards had to be faced.

The area had, however, the paramount advantage of a high elevation, the overflow cill of the dam being 1,065 ft. above Ordnance Datum, the effective head being 920 ft. It has a further advantage in respect of its high rainfall of fully 70 in. per annum, and, by the terms of purchase, the water rights were bought outright, so that no compensation to the river has to be provided for.

The reservoir, probably the largest artificial one in Europe, has a length of 7½ miles, and an average width of about half a mile. It impounds about 20,000 million gallons of water, sufficient to give an output of 30,000 h.p. for about one hundred days. The cost of the works proper was £600,000, or £20 per horse-power.

In 1909 Mr. Morrison, manager of the company, stated that the output of the plant was 150,000,000 units per annum, and he compared this with the annual requirements of the London County Council, 97,000,000 units; and of Glasgow, for trams and lighting, 63,000,000 units.

The requirements for electric traction in the United Kingdom for 1909 were 253,000,000 units.

After allowing for interest on capital and depreciation, the total cost of the current was one-sixteenth of a penny per unit, and he hoped it would ultimately be one-twentieth of a penny. This figure is, of course, arrived at on a load factor almost approaching unity. One-sixteenth of a penny per unit is, approximately, 34*s.* per horse-power per annum continuous working.

It is interesting to note that in this case all the water had to be artificially impounded, whereas, in many cases, the existing lochs could be advantageously utilised.

The feature of the Kinlochleven scheme is the excellent fall available. If the method adopted in arriving at the powers shown on our map be applied to this area, the power available would be about 17,500 h.p. Having developed the

power in the Leven basin the company are now asking Parliamentary authority to utilise the Laggan basin. The same company has also 7,000 h.p. installed at Foyers on Loch Ness.

As an example of a small installation, that at Raven's, near Strathpeffer, may be instanced. The water is drawn from a small dam costing little more than an ordinary farm mill-dam, and on a head of 600 ft. develops 120 h.p., and supplies current for lighting and power to Dingwall and Strathpeffer.

There are installations at Stanley, Blair Castle, Loch Rosque, Achnasheen, Evanton Village, Ardross Castle, Fochabers, North Esk, and elsewhere.

Attractive possibilities exist in the stretch of the Caledonian Canal between Loch Ness and Inverness. Loch Ness drains approximately 700 square miles, and the level of it is 50 ft. on Ordnance Datum. The stretch of the Canal referred to is the same level as the loch, and by drawing from it such a quantity of water as would not interfere with navigation, 3,000 h.p. for the working days of the year could be got at Inverness.

Another attractive area is that drained into Loch Luichart near Strathpeffer. The loch drains 149 square miles of very wet country, and has an area of 1,150 acres. The river flows out of the loch in a series of cascades, and falls 125 ft. in a length of 850 yards. Two-thirds of a 42-in. rainfall would, under these conditions, represent 6,000 h.p. on a twelve-hour day basis. The outlet of the loch is a narrow rocky gorge, and impounding could be easily and cheaply carried out.

The possibilities of Lochs Morie and Glass, on the east shoulder of Ben Wyvis, are worth investigation. These lochs are at elevations of 621 ft. and 712 ft. respectively, and the combined powers from them, if developed on the shore of the Cromarty Firth, amount to 12,800 h.p.

The elevated area—approximately 1,500 ft.—between Glen Moriston and Glen Urquhart on Loch Ness is also worth looking into.

Power from Rivers.

Although we have so far been considering the development of power in bulk by utilisation of the impounded waters from large, elevated drainage areas with heavy rainfall, there are considerable and widely distributed possibilities of power development in many rivers and small streams all over the country.

What strikes one in moving about the country is the number of small water power sites now long abandoned.

In the economic development of a country these small powers are well worthy of consideration.

Previous to the invention of the steam engine, about 1790, the only sources of power were water and wind; but the potentialities of steam rapidly drove these humble competitors from the field. The inception and growth of railways as a means of transport also assisted in this. Railways linked up the principal centres of population and carried coal there cheaply, and so established them as centres of industrial development, and rural industry was strangled.

The use of water power in the growth of the great industries of the English northern counties is referred to by Mr. Edwin A. Pratt, in "History of Inland Transport." He writes:—

"The textile industries originally established in the eastern counties by refugees from the Netherlands and France afterwards spread through the southern and western counties, attaining in each district to a very considerable growth long before they were of any importance in those northern counties with which they were afterwards mainly to be associated. The migration to the north occurred at a time when the woollen industries were paramount and the cotton industries had still to attain their subsequent stupendous growth. It occurred, also, long before the Aire and Calder were made navigable, so that, in this case, we cannot say the industrial centres already mentioned as being situated on or near to those two Yorkshire rivers were set up there, as the towns on the River Severn had mainly been, in order to secure the convenience of river transport.

"The chief reason why the bleak and barren moorlands of the north were preferred to the fair and fertile plains of the south for the further expansion of these great national industries was that, in the days when the steam engine of James Watt was as yet far off, the heavier rainfall in the English Highlands of the north and north-west, together with the more numerous streams pouring down mountain-sides both of greater height and greater extent than in the south, gave to the clothmakers, not only the abundant water-supply they wanted, but also the particular kind of motive power, through the use of water-wheels, on which they then mainly relied for the working of their machinery.

"It was in the interests of this power derived from falling water that the textile industries first migrated from the eastern counties—where the

streams flow but slowly, and from comparatively slight elevations—to the western counties, where there are streams coming from hills of from 800 to 1,000 ft. in height. These, for a time, answered better the desired purpose, though only to be more or less discarded in turn for northern or north-western streams which, with a greater rainfall, had their rise on heights of from 1,500–2,000 ft. and were so numerous that almost every one of the small manufacturers who set up business for himself on the otherwise cheerless slope of a Yorkshire hillside, could have a brook, rivulet, or a mountain torrent of his own, or at least make abundant use of one before it passed on to serve the purposes of his neighbour.

"In alluding to the woollen trade as affected by these conditions, Dr. Aikin remarks, in his 'Description of the Country from Thirty to Forty Miles round Manchester' (1795): 'It would seem as if a hilly country was particularly adapted to it, since it almost ceases where Yorkshire descends into the plain'; though the position has, of course, been entirely changed by the general resort to steam in preference to water power.

"Other industries, besides those relating to textiles, whether woollen or, at a later period, cotton, took advantage of the same favourable conditions as shown in the case of Sheffield, where the earliest of the cutlers who were to make Hallamshire goods famous throughout the world, settled down at the confluence of the Sheaf and Don because those streams afforded them the best available means of operating their tilt-hammers."

The development of small powers from suitable streams is a relatively simple and inexpensive matter. In the case of large rivers, however, it is difficult economically to utilise even a considerable part of the normal flow owing to the cost of devising a cheap scheme for dealing with a large volume of water on the low fall normally available. It has been stated that turbines, for a head of 25 ft., cost £4 per horse-power, as against £1 per horse-power for a head of 500 ft. A high fall is the ruling factor in all economically developed power schemes.

The extraordinary variation in the flow of rivers has been already illustrated, and if it be assumed that 20 cubic ft. per minute per square mile be available for power this represents ·03 h.p. per foot of fall. A river like the Spey, draining 1,100 square miles, would, therefore, represent on a 15 ft. fall, requiring about a mile of power water flume, 500 h.p. On many reaches of such a river where the fall is much greater and the drainage area less, the power available would, however, be much greater, owing to impounding being possible. On certain large Irish rivers it has been calculated that 50 cubic ft. per minute per square mile is available for power, but in any scheme involving the use of such a quantity of water it may be assumed that a considerable fall is available. Dr. Mill, in one of his publications, gives the drainage areas of certain Scotch rivers as under:—

River.	Sq. Miles.
Tweed	1642
North and South Esk	683
Dee	816
Don	512
Deveron	599
Spey	1148
Ayr.	223
Dee (Kirkcudbright)	386
Annan	374
Esk	381

Attention was recently directed to the steepness of the gradients of northern Scottish rivers, in consequence of a statement by Mr. Alexander Ross, past-President of the Institute of Civil Engineers, who, in a presidential address, advocated the drainage of the Spey meadows, and said that the Spey was probably the most rapid river in Scotland.

This directed attention to other rivers, and some controversy took place, as the result of which Mr. C. H. Roberts, Aberdeen, claimed for the Aberdeenshire Dee the distinction attributed to the Spey, while Mr. Jenkins, Aberdeen, claimed it for the Findhorn.

These gentlemen published particulars on these gradients, which are worth reproduction (see p. 177). Mr. Jenkins says the Don is industrially the most useful river in Scotland.

Owing to the difficulty in arriving at total powers available directly from river flow, I have not shown anything derivable from this source on the map, which shows power obtainable from impounded areas only.

Economic Value.

The powers shown on the map total up to 375,000 h.p., and it is believed they are arrived at on a conservative basis. Assuming that these powers are looked upon as a national asset, the development of them to their maximum efficiency should be carried out under statutory control.

Unless this be done, the perpetual right to

Levels above Ordnance Datum.	Average fall in ft. per mile. River Dee.			River Spey.	
Between 4,000 and 2,000 ft.	840			—	
„ 2,000 „ 1,750 „	87			—	
„ 1,750 „ 1,500 „	87			—	
„ 1,500 „ 1,250 „	65			—	
„ 1,250 „ 1,000 „	21			22	
„ 1,000 „ 900 „	21			40	
„ 900 „ 800 „	27			8	
„ 800 „ 700 „	30		46	7	
„ 700 „ 600 „	32			5	
„ 600 „ 500 „	30	20		14	11½
„ 500 „ 400 „	15			17	
„ 400 „ 300 „	17			15	
„ 300 „ 200 „	17			14	
„ 200 „ 100 „	13			14	
„ 100 „ sea level	6½			16	

	Average fall in feet per mile. On total length of river.	From mouth to 1250 feet contour.
Findhorn . . .	50	27¾
Dee	46	16⅔
Don	24	17
Spey	—	11½

them will be absorbed by private enterprise, and so be lost for all time to the nation. It does not follow that private enterprise should not be encouraged to develop the powers, but this could be done under statutory authority whereby it would be possible for the State to acquire the powers if and when it required them for national purposes, or to buy them up altogether under a pre-arranged basis of purchase, in the same manner as at the inception of the railway movement the Government retained an overriding interest in all railways.

Such a control could, moreover, ensure that by generating current of the same periodicity at every power station the whole of them could be made to feed into a network of transmission lines. In this way abnormal rainfall in areas widely apart could be converted into power and not be lost.

In Canada the preservation of water rights has been legislated for in a very thorough manner. In "Water Powers of Canada" an estimate, which is really a "hazard" in the absence of reliable information, places the power available as 17,000,000 h.p.

The amount developed in 1911 in the ten provinces was as under, the figures for Ontario Province, which controls the Niagara Scheme and the Ottawa River, and which is the largest consumer, being shown within brackets:—

	Horse-power.
Electrical Energy	742,955
Ontario	(400,683)
Paper and Pulp	158,051
Ontario	(57,575)
Other industries	115,515
Ontario	(74,008)
Totals.	1,016,521
Ontario	(532,266)

Speaking with respect to Ontario's possibilities on April 19th, 1905, Premier Whitney said: "The water power of Niagara shall be as free as air, and more than that, I say on behalf of the Government that the water powers all over this country shall not in future be made the sport and prey of capitalists, and shall not be treated as anything but a valuable asset of the people of Ontario whose trustees the Government of this people are."

These powers in Ontario are now to be had under statutory leases, granted under the seal of the Lieutenant-Governor.

Of a list of twenty-four leases granted since 1898, nine are for ten years and fifteen for twenty years, a typical rental for a twenty years' lease for 2,000 h.p. being, per horse-power, first and second years, $10; then 50 cents per horse-power; minimum payment, $1,000.

At the expiry of the lease the lands, buildings and powers, revert to the Crown, together with dams, weirs, tunnels, races, flumes, sluices, pits, and other structures, the lessees being at liberty to remove the machinery, there being a proviso that where buildings and structures are of a permanent character and necessary for useful and proper development the Lieutenant-Governor may, on the advice of the Hydro-Electric Commission, purchase them.

The Ministry of Reconstruction Sub-Committee recommend sixteen stations of normally 20,000 h.p., or a total of 320,000 h.p., say 400,000 h.p.—about what is shown on the map.

If carried any great distance the Scottish powers would have to be reduced to, say, 60 per cent. efficiency to allow for conversion and transmission losses, but even then their total would amount to 300,000 h.p.

Mr. Archibald Page, Glasgow, has given the power requirements of Scotland at end of 1916 as under:—

	Horse-power.
Municipal and Company-owned—actual load	263,000
(Capital cost, £47 per kilowat on a plant capacity of 221,000 kilowats.)	
Privately-owned electric plants	219,000
Direct driving by steam and gas engines	637,000
Total	1,119,000

It would appear, therefore, that there is sufficient water power in the Scottish Highlands to meet a large part of the demands of industrial and municipal requirements in Scotland, but, on the other hand, it is doubtful if the cost after development and transmission to existing industrial areas would be less than the cost of power generated there at the pit-head. It may be, therefore, that the sphere of usefulness of these water powers is the region in which they are available, along with a fringe of the adjacent territory to which they could be transmitted. This, however, is probably one of the most interesting features of Scottish water power. It exists in a territory destitute of coal, and it is due to the presence of, or accessibility to, cheap coal that the great centres of industrial activity are located where they are. It may be said that shipping facilities also determined their location, but such facilities exist all over the northern half of Scotland. If it be true, therefore, that our industrial growth was due to cheap coal for the steam engine, it is equally true that activity centred round the main shaft of the engine because power transmission to any distance was, from a steam source, both tremendously expensive and wasteful. The simplicity with which electrical energy can be transmitted and applied by means of multiple driving has changed all this, and decentralisation of industry has become possible. But is decentralisation desirable? What is the situation as we find it to-day?

When the long-looked-for day of peace arrives, it may be found that Great Britain is a debtor nation to as great an extent as in pre-war days we were a creditor nation, and strenuous effort, much of it in new directions, will be required of us industrially in the future. The demands of labour for the administration and control of industry become increasingly insistent as the war goes on, and this and the position of women as industrial workers, as well as improved housing, are questions which will require far-reaching and meantime indeterminate adjustments when our economic life is resumed on the conclusion of peace.

The extent to which we have neglected the agricultural possibilities of our country is also causing anxiety to reflective minds. We were quite content in times of peace and plenty to grow 1,500,000 tons of wheat and to import 5,500,000 tons, and few of us ever contemplated an existence under which the Russian and Rumanian wheat crop would not be available for our needs, and when even our food supply from America and our Colonies can only reach us by a trade route infested by pirates.

Even before the war emigration and depopulation of our rural districts, with a corresponding augmentation of our city populations, was a disturbing consideration, and efforts were made to show that what was the Mother Country's loss was our Colonies' gain, and that, therefore, the balance was maintained.

It was argued for instance, as a comforting thought, that from 1861 to 1911 the population of Greater London had increased by almost exactly 4,000,000. In that year—1911—the population was 7,251,000, almost exactly that of Canada, fully one and a half times that of Australia, and more than seven times that of New Zealand.

The increased population in all the larger towns varied to some extent, but was a feature of them all, and, as a matter of fact, we were told that only 22 per cent. of the people of Great Britain and Ireland lived under rural conditions. The fact that a nation's wealth consists in a healthy, contented peasantry was lost sight of, and the race was being allowed to degenerate in the fœtid vortex of industrial life in great cities. Moreover, we were content to make up any loss due to emigration by the utilisation of an influx of alien peoples that was beginning to flow in unrestrictedly.

Much of this condition of things is attributable to the centralisation of industry, which has absorbed our rural population to an increasing extent year by year.

The slump in agriculture and the strangulation of rural industry made existence for a rural population impossible, and employment in industrial centres, or emigration, were the only alternatives.

Now we have the cry of "back to the land," and a demand for afforestation, which latter undoubtedly offers vast and far-reaching remedial possibilities. Both of these schemes should, however, as far as possible be associated with an industrial development, and where water power exists this is eminently practicable. Moreover, it will be surprising if the broadcast distribution of electrical energy adumbrated by the Coal Conservation Committee does not have the effect of gradually extending the borders of the present congested industrial centres, thus rendering possible better housing conditions and a more attractive environment for the workers, the want of which is at the bottom of much of the industrial unrest we read of.

But if this eventually be possible within the area of activity to be served by the sixteen super-generating steam-driven stations, what of the coalless territory beyond the range of these? Such territory must either resort to water power, if it exists within its borders, or, industrially, it must become derelict.

North of a line drawn from the Firth of Tay to the Firth of Clyde lies about 66 per cent. of the total area of Scotland, that is to say, 18,000 square miles out of a total of 27,400. The population in this region, excluding Perth and Dundee, is approximately 1,100,000, or only 23 per cent. of Scotland's total. The Highland peoples in this northern area have passed through many vicissitudes since the feudal days when they did nothing but fight each other, but their capacity to fight and endure, either in doing their share of the world's work in times of peace, or for the defence of liberty, as at the present time, is yet unimpaired.

It is in territory such as this that a keen discriminating intellect is developed, and that the brawn and muscle of the British race is bred and reared, and not in congested hives of industry, and if employment can be found for such a people in their home environment it is all to the nation's interest to provide it.

The great bulk of the northern population is located in the towns and villages on both shores of the Moray Firth, from Peterhead on the one hand to Wick on the other. The "Laigh of Moray" eastwards, and also Easter Ross, are two of the richest agricultural districts in Scotland.

If we are to witness the birth of an industrial-cum-agricultural era in this part of the country, it follows that sufficient Highland water power must be conserved for the purpose. Objection is sometimes made to a plea for industrial development in rural districts, by contending that such districts lie beyond the range of raw material supply. Such objection overlooks the fact that much of our finer industrial output requires little raw material. Its value lies in the workmanship put into it and not on the weight of it. It is sold per unit and not per ton. The Consolidated Tool Company of Great Britain laid down their works at Peterhead, the Arrol Johnston Motor Company migrated from Glasgow to Dumfries, and the large business of the "K" Boot Company is located at Kendal.

Apart also from experiments in intensive agriculture such as are now being carried on in Hereford, farming operations generally could well participate in the broadcast distribution of electricity for lighting and power for all the multitudinous operations carried on in the field and in the farm buildings.

The real advantage of combining industry with agriculture on any scheme of land settlement is that the industrial employment supplements the living on the croft or small holding, which of itself will not provide a sufficiently remunerative and attractive livelihood.

Dr. Scott, Professor of Political Economy, Glasgow, in a report to the Scottish Board of Agriculture, strongly advocates the initiation of a scheme of home industries using power in the Highlands.

The working up of wool, timber, hides, peat, building materials, sandstone, limestone, granite, marble, slate, etc., is work which can be entered upon at any time, and in the Memoirs of the Geological Survey on Mineral Resources of Great Britain, we read of the deposits of pegmatite, or "graphic granite," which exists in Sutherlandshire, and from the felspar in which, equal to 72·5 per cent. of the whole, potash can be extracted. Between Lochs Laxford and Inchard it is estimated that 190,800 tons of pegmatite is available. Further deposits exist at Durness and Eribol, and at Overscaig on Loch Shin. The residue from potash felspar can be used as a fertiliser, and as a glaze in pottery, enamel and electric ware and other purposes.

Since writing the foregoing I observe that Mr. E. A. Ashcroft, speaking at the Institution of Mining and Metallurgy, says there are in the extreme north-west of Sutherlandshire, and within reach of admirable shipping facilities, 12,000,000 tons of pegmatite in intrusive veins of a total

width of a quarter of a mile, ideally situated for open quarrying operations. He estimates that, from a plant which he specifies, 50 tons a day of 80 per cent. potassium muriate could be obtained equal to what is obtained from all the 300 blast furnaces in the country put together. These Scottish deposits would alone suffice to maintain twice such an output for fifty years at a cost not exceeding £7 a ton, and not more than £15 to £20 a ton even under war conditions.

Graphite exists more or less freely in several localities, such as Loch Carron and Loch Maree. Heddle, in his "Mineralogy of Scotland," says in Glen Strathfarrar in 1818, five tons were quarried at £13 a ton and sold for £93 a ton. It is also to be got at Invergarry, Huntly, and elsewhere. Molybdenite and chromite are also to be got, the latter being especially abundant in Shetland, where previously many thousand tons of it were obtained. Steatite exists in various localities, and the Skye diatomite, which contains 97·78 per cent. of silica after being heated to expel the water, is well known. Diatomite is also found in Tolsta Lewis, and in Mull. The iron, consisting largely of brown hematite, at Tomintoul is worth mention. It was first worked at the beginning of the eighteenth century, and contained as much as 72·72 per cent. of pure iron. The iron deposits in Raasay are now well known. Lead ore is meantime being worked at Georgemas, and barytas near Lybster, both in Caithness.

ENGLAND AND WALES.

I have purposely, in referring to Scotland, dealt with every aspect of my subject, for the reason that it is best to follow out one's argument to a conclusion, and for the further reason that what has a general bearing on the situation in Scotland applies with equal force to England and Wales and Ireland.

For purposes of loose approximate comparison, and on the assumption that one-third of all rainfall flows to the sea, I have prepared the following table:—

	Area.	Average elevation.	Total rainfall.	Horse-power.
	Sq. miles.	Feet.	Inches.	Continuous.
Scotland	27,400	450	48	1,200,000
England	50,000	250	32	900,000
Wales	7,400	450	51	350,000
Ireland	32,700	400	42	1,150,000

From the above, if the figure already arrived at for Scotland be assumed correct, on the same ratio the power for the other countries would be:—

	For 12 hours' daily supply.
England	281,000
Wales	109,000
Ireland	359,000

If based proportionally on the 50-in. rainfall areas in each country, the powers would be:—

	50-inch area.	Horse-power.
	Square miles.	
Scotland	11,575	375,000
England	3,360	108,000
Wales	3,390	109,000
Ireland	5,910	190,000

Neither of the above results can possibly be of the slightest value, although it is a striking coincidence that the resultant for Wales is the same in both of them.

There are very much greater rivers in England than in Scotland, but remarkably few lochs, which are such an outstanding feature of Scotland.

The following is a list of rivers and catchment areas from Dr. Mill's pamphlet:—

River.	Sq. miles.	River.	Sq. miles.
Solway	1,280	Southampton Water, etc.	1,052
Lune	435	Rother	411
Ribble	707	Medway	673
Mersey	1,693	Thames	5,310
Dee	843	Blackwater	425
Towy	778	Yare	1,234
Usk	594	Ouse	3,168
Wye	1,599	Nene	917
Severn	4,384	Welland	658
Lower Avon	884	Witham	1,107
Parrett	636	Trent	4,017
Taw	442	Ouse	4,187
Exe	572	Tees	809
Stour	488	Wear	464
East Avon	680	Tyne	1,130

From Mill's survey of the "English Lakes" we get the following information, and, dealing

with it in the same way as for Scotland, we arrive at the following results:—

Loch.	Height.	Drainage area.	Area of Loch.	Fall.	Horse-power.	Point of Development.
	Feet.	Sq. miles.	Sq. miles.	Feet.		
Windermere	130	88·65	5·69	110	3,300	At sea-level.
Ullswater.	476	55·95	3·44	—	—	—
Wastwater	200	18·64	1·12	180	1,100	At sea-level.
Coniston	143	23·34	1·89	120	—	—
Buttermere	329	6·50	·36 }	150	1,150	On 150-feet fall.
Crummock	321	16·80	·97 }			
Ennerdale	368	16·95	1·12	300	1,700	At sea-level.
Bassenthwaite	223	*91·51	2·06	100	3,100	On 100-feet fall.
Derwentwater	244	31·83	2·06	—	—	—
Haweswater	694	11·20	·54	200	750	On 200-feet fall.
					11,100	
				(Say	11,000)	

* Excluding Derwentwater and Thirlmere.

as is usually found in mountainous country. Careful investigation with the aid of maps would very probably disclose considerable possibilities of power by collecting and impounding the yield from adjoining areas.

The Lake District is one of England's beauty spots, and objection on æsthetic grounds might be made to any interference with the natural charm of it, but the utilisation of the lakes for power development would not, of necessity, mar the beauty of the natural features any more than did the construction of the Thirlmere Reservoir. At the same time, seeing that coal exists on the western border of the district, it does not appear likely that the English Lakes will be requisitioned for power at least for some time to come.

The reference to Thirlmere directs attention to the fact that in England the requirements for domestic water-supply obtrude themselves much more prominently than in Scotland, seeing that the density of population is much greater and the average rainfall much less.

For Wales, with the assistance of Professor Jehu's figures and one-inch maps, from which I roughly calculated a number of drainage areas, I have prepared the table given on p. 182.

The lochs dealt with are all in North Wales—in Snowdonia—and in eastern Carnarvonshire. Generally speaking, the whole of the Welsh lochs are small. Many of them are at great elevations, but, unfortunately, these, as a rule, drain very small areas. I have no particulars of the North Wales Power Company, and do not know where they generate their power. The orographical features of Wales are extremely confused, and seem to follow no sort of system such as is usually found in mountainous country.

The absence of large lochs in England and Wales, and the want of elevation in the country as a whole, severely restrict the possibilities of water power development.

The direct flow of rivers appears to be the principal source of energy available, and owing to the variation in flow, and for the other reasons stated, no great amount of power appears to be economically available.

What has been done on the Dee at Chester is an interesting and recent example of utilisation of river flow. Mr. James Gordon, who installed the plant, has given me certain particulars The Dee drains 713 square miles above Chester and by utilisation of the old Roman weir on the river there, the yield from this catchment area is passed through turbines and, judging by the units generated, appears to develop about 500 h.p. on a fall varying from 1 ft. to 9 ft.

If the average fall be called 5 ft. the power per square mile of drainage area per foot of fall $=\frac{500}{713\times5}=14$ h.p., requiring 90 cubic ft. per minute per square mile, or about four times what I suggested for the Scottish rivers. The average flow of the Dee at Chester is given as 90,540 cubic ft. per minute = 127 cubic ft. per minute per square mile, and this is said to represent 56 per cent. of the rainfall in the

Loch.	Drainage area.	Elevation (above sea).	Fall utilised.	Horse-power.	Where developed.
	Sq. miles.	Feet.	Feet.		
Lochs Gwynant and Dinas	15	175	150	770	Pant Aber Glasslyn.
Padarn and Peris	23	339	300	2,350	On Menai Straits.
Llydaw	1½	1,416	1,200	600	Llyn Gwynant.
Cwellyn	8	463	200	550	On 200-feet fall.
Ogwen	6	984	400	800	Bethesda.
Cawlyd	1½	1,164	1,100	560	Dolgarrog.
Llyniau Mymbyr	18	588	500	3,000	Bettws-y-Coed.
Eigeau	4	1,219	1,200	1,600	Porth Llwya.
Crafnant and Geirionydd	3½	616	600	700	Trefriw.
Dulyn and Melyn	1½	1,747	1,700	850	Tal-y-Bont.
Conwy	2¼	1,488	750	560	Yspytty-ffan.
	(Say	12,000)		12,340	

(Powers are calculated in the same way as the Scottish powers.)

catchment. Judging by the time-lag shown in the monthly flow and rainfall figures, the river has a very flat gradient.

IRELAND.

Like England, Ireland's possibilities of power appear to be principally in her great rivers.

The peculiar geographical feature of Ireland is that a great part of the interior of the country is a flat plateau of varying elevation, but nowhere at any great height above sea-level. In this plateau flow great sluggish rivers which have a steep fall to the sea for the last few miles of their length.

This feature of the rivers makes them extremely valuable for power production. I have read two excellent papers on Irish water power, one by Mr. Tatlow and the other by Mr. Dick, and as neither of these gentlemen, with their knowledge of the country, ventures to bring out a grand total of the powers available, it is much to be desired that someone should undertake this.

So far as my information goes, the best of the lochs lie in flat arable or grazing country, and the raising of their level by impounding would flood much valuable territory.

Mr. Dick makes an estimate of powers from a number of rivers, including the Erin, Corrib, Shannon, Bann, Lee, Inny, etc. From what he calls "minimum" flow he estimates that "constant" power is available; from "normal" flow "ten months'" power, and from "augmented" flow (which includes floods), "seven months'" power.

The amount of power as given by him is as under:—

"Constant" power	5,916 h.p.	
10 months' ,,	11,832 ,,	
7 ,, ,,	23,664 ,,	

The total is not very imposing, especially as other writers claim for the Erin alone from 30,000 to 300,000 h.p.

Mr. Dick says that the normal flow—*i.e.* giving ten months' power, may, for areas of 30 square miles and upwards, be taken as 25½ cubic ft. per minute per square mile, being only slightly more than what I estimated for Scotland.

To recapitulate briefly, if we are to pay for this war by acceleration of our industrial activities any scheme for the broadcast distribution of cheap power is of the utmost importance. Water power provides great possibilities in coalless territory and where coal cannot be cheaply imported.

Cheap power means the more universal application of it, with a consequent release of man-power which for many years will be scarce and expensive. Canada at the present time uses about one and a half times the amount of mechanical energy per worker that we do. Schemes for national reconstruction and social betterment are meantime rife, and much is expected of a sound practicable land policy.

I have elsewhere contended that any successful policy for an agricultural renaissance must

be associated with an industrial policy, and utilisation of water power and afforestation are pre-eminently attractive from this point of view.

The rural homes throughout the country are occupied by old people, maintained by their sons and daughters employed in the great cities, and unless the younger generation be found remunerative and attractive employment where they are born they will not settle down there. Moreover, the poverty of our rural districts has been for long attracting attention, and unless something be done which will increase the rateable value there, it looks as if taxation for public services, such as education, poor, roads, sanitation, etc., will eventually have to be met by the State.

Already in some districts in the north of Scotland taxation is in excess of the gross rateable value, and such a condition of things is economically destructive in any State.

It is much to be desired that such work as that done by the British Rainfall Organisation and the Scottish Meteorological Society should receive more support and recognition than it does.

Notwithstanding present-day developments in scientific research, there are still those who believe that the recording of rainfall, temperature, hours of sunshine, and direction of wind currents, is little more than a "harmless craze."

It is quite possible, however, that the development of aerial flight, which will be of immense interest in the future, will direct attention to this branch of science, and that the work of past and present meteorologists will yet be appreciated as it deserves to be.

The paper was illustrated by a number of interesting lantern-slides.

APPENDIX.

SCOTLAND.

Lochs, Drainage Areas, Fall available and Power possibilities, assuming that 24 hours' yield from Catchment Area is utilised in 12 hours; based on ⅔ of a 42-inch rainfall. Efficiency, 75 per cent.

Name of Loch.	Height above sea.	Drainage Area.	Area of Loch.	Fall utilised.	Horse-power.	Point of Development.
	feet.	sq. miles.	sq. miles.	feet.		
Wick—						
Loch Hempriggs . . .	153·7	9·39	·34	140	400	At seashore.
Loch Shurrery	321·45	28·89	·36	300	2,900	Forss.
Naver—						
Loch Syre	412·8	5·34	·17	400	720	Bettyhill.
Loch Naver.	247·6	88·78	2·26	90	2,720	Syre.
Loch Coire Na Fearna .	569·7	24·48	1·15	400	3,360	"
Loch Na Meide . . .	488·35	8·05	·87	240	700	Altnaharra Loch Naver.
Borgie—						
Loch Loyal—	369·9	33·05	2·55	350	3,060	Torrisdale. Sea coast.
Kinloch—						
Loch An Dithreibh . .	267·45	12·66	·74	250	1,100	Kyle of Tongue.
Laxford—						
Loch Stack	117·65	40·20	·99	100	1,400	Loch Laxford.
Loch Nam Blarloch . .	400 (?)	12 (?)	—	400	1,500(?)	Loch Inchard.
Loch Strath Nan Caran .	500 (?)	7 (?)	—	500	1,200	Loch Glendhu.
Loch Allt-na-h-Airbhe .	119·5	8·73	·13	100	300	Loch Cairnbawn.
Inver—						
Loch Assynt	215·1	43·13	3·10	200	2,950	Lochinver.
Loch Druim Suardalain .	134·5	12·86	·12	120	530	"
Loch Fionn.	356·9	52·88	·33	350	6,360	Inverkirkaig.
Loch Urigill	514·7	10·98	·78	150	570	At Fionn Loch.
Loch Awe	504	3·21	·13	300	300	Inchnadamph.
Loch Tuire	200 (?)	2·95	·08	200	200	Clashnessie.
Loch Skinaskink . . .	245·1	15·58	2·09	240	1,280	Enard Bay.
Loch Owskeich . . .	72	20·03	·65	75	500	" "

Name of Loch.	Height above sea.	Drainage Area.	Area of Loch.	Fall utilised.	Horse-power.	Point of Development.
	feet.	sq. miles.	sq. miles.	feet.		
Broom—						
Loch Achall	263·4	28·85	·52	250	2,500	Ullapool.
Loch À Bhraoin	812·3	13·03	·66	800	3,500	Loch Broom.
Loch Droma	884·1	3·00	·18	870	900	,, ,,
Loch Na Sheallag	277·7	36·94	1·37	270	3,400	Gruinard Bay.
Loch Fionn	558·6	26·55	3·52	540	4,900	,, ,,
Loch Fada	498·1	2·29	·23	490	380	,, ,,
Gairloch—						
Lundie	750	5·20	—	700	1,240	Shieldaig.
Na-h-Oidche	1,250	2·91	·54	1,200	1,200	Loch Maree.
Bad-na-Sgalaig	352·6	9·75	·22	330	1,100	Gairloch.
Ghobhainn	1,000	11·13	·59	950	3,650	,,
Horrisdale	302·3	3	·14	275	280	,,
Carron—						
Sgamham	491·6	7·51	·22	370	950	Achnashellach.
Alsh—						
Bhealaich	1,242·6	1·77	·12	1,200	700	Kintail, Loch Duich.
Morar—						
Loch Morar	30·5	65·63	10·30	30	700	Shore.
Loch Borraraid	168·0	11·85	·55	130	520	On Loch Morar.
Aline—						
Tearnait	460	4·16	·17	450	640	Aline, Sound of Mull.
Feochan—						
Scamadale	221	13·35	·35	200	910	Loch Feochan, S. of Oban.
Leven— (British	Aluminium Co.,		Kinloch	leven.)	30,000	Kinlochleven.
Eilde Mhor	1,100	6·16	·38	1,050	2,200	,,
Lochy—						
Loch Arkaig	139	88·27	6·24	40	1,220	Loch Lochy.
Loch Pattack	1,419	18·18	·27	600	3,740	At Loch Laggan.
Loch Laggan and Treig	(800)	104	5·38	720	25,700	S. end of Loch Lochy.
Loch Ghuilbruin	1,160	29·13	·23	360	3,600	At Loch Treig.
Loch Lunn du Bhra	510	1·13	·10	500	200	On Loch Linnhe.
Ness—						
Quoich	556	49·18	2·86	300	5,000	Loch Garry.
Garry	257	137·33	1·75	150	7,000	Invergarry, Caledo'n Canal.
À Bhainne	1,060	1·81	·05	960	600	,, ,, ,,
Lundie	445	3·44	·17	350	400	,, ,, ,,
Clunie & Loyne	(720)	56·16	(1·77)	650	12,500	Invermoriston, Loch Ness.
An Staca and Liath	1,450	5·23	·36	1,150	2,000	On Invermoriston River.
Nam Breac Dearga	1,570	·60	·09	1,500	300	Alltsigh, Loch Ness.
Leath	1,494	4	·10	1,440	2,000	,, ,, ,,
Vullan	1,750	·69	·04	1,400	300	L. Meiglie, Glen Urquhart.
Loch Meiglee	364·9	41·32	·31	300	4,300	Drumndrochit.
Loch Aslaich	1,310	1·62	·03	1,250	700	Borlum, Glen Urquhart.
Loch Laide	859·8	1·55	·06	800	420	Abriachan, Loch Ness.
Tarff	956·2	1·20	·21	900	370	Loch Ness.
Knockie and Nan Lann	(675)	3·69	·38	600	760	,, ,,
Loch Kemp	577·8	1·53	·11	520	280	,, ,,
Foyers Area (belonging	to the	British	Alumini	um Co.)	7,000	Foyers, Loch Ness.
Loch Killin	1,044	38·45	·20	400	5,000	At Foyers Reservoir.
Ruthven	701	4·01	·57	650	900	Loch Ness.
Beauly—						
Loch Mullardoch	705	53·86	1·29	500	9,200	Cannich Strathglass.
Loch Beinn À Mheadhoin (Loch Affric 747)	700	67·98	1·74	500	11,600	,, ,,
Loch Monar	663·9	50·06	1·17	230	3,900	At Loch À Mhuilinn.
Loch À Mhuilinn	417·65	87·82	·16	250	7,500	Struy.

Name of Loch.	Height above sea.	Drainage Area.	Area of Loch.	Fall utilised.	Horse-power.	Point of Development.
	feet.	sq. miles.	sq. miles.	feet.		
Conon—						
Loch Achanalt	365	72·63	·25	100	2,500	At Loch Luichart.
Loch Fannich	821·9	35·69	3·60	560	6,850	" "
Loch Luichart	249·8	149·45	1·76	150	7,500	Below Falls of Conon.
Loch Garve	218·8	113·97	·59	120	4,600	Contin.
Loch Glass	712·9	25·35	1·86	675	5,800	Evanton, Cromarty Firth.
Loch Morie	621·6	35·28	·92	600	7,000	Alness, " "
Shin—						
Loch Shin	270·85	190·29	8·70	250	16,000	Invershin.
Loch Merkland	360·2	15·94	·69	80	440	On Loch Shin.
Loch Gorm, Loch Mhor	847	10·00	—	560	1,920	" "
Loch Migdale	113·6	7·21	·41	100	240	Spinningdale, Dorn'h Firth.
Loch Buidhe	582·45	8·70	·21	500	1,500	The Mound.
Brora—						
Brora	92·9	120·84	·88	80	3,350	Sea-level, Brora village.
Helmsdale—						
Araich-Lin	451·8	15·03	·18	280	1,450	Kildonan Station.
Loch-na-Moine	376·6	55·78	·14	200	3,840	" "
An Ruathair	414·8	11·24	·82	250	940	" "
Ewe—						
Lochan Fada	1,005	9·37	1·44	970	3,100	Kinlochewe, Loch Maree.
Loch Garbhaig	1,010	2·41	·23	970	800	Loch Maree.
Loch Clair	303	34·46	·42	260	3,000	Kinlochewe Loch Maree.
Loch Tollie	387	2·00	·26	350	240	Loch Maree, W. end.
Loch a Bhaid Luachraich	309·6	3·91	·51	300	400	Loch Ewe.
Eachaig—						
Loch Eck	66·6	39·40	1·70	50	700	Holy Loch.
Etive—						
Loch Tulla	542·3	56·94	1·10	410	8,000	N. End Loch Awe.
Loch Awe	117·9	291·18	14·85	100	10,000	Loch Etive.
Loch Avich	310·85	11·36	1·21	200	750	On Loch Awe.
Loch Nant	606	9·38	·22	600	1,900	Loch Etive.
Doon, Ryan—						
Bogton (Loch Doon)	522·6	59·81	·09	500	10,000	On coast.
Luce—						
Trool	246·35	14·26	·23	220	1,000	Newton Stewart.
Loch Mayberry and Dornal	387	9·64	·44	350	1,150	" "
Dee, Kirkcudbright—						
Loch Ken and Dee	145	297	1·36	120	12,000	Kirkcudbright.
Loch Rutton	305	3·15	·20	270	300	Mouth of River Nith.
Clyde—						
Loch Sloy	810	6·28	·10	770	1,600	Loch Lomond.
Tay—						
Loch Ericht	1,153	50·39	7·21	470	8,000	On Loch Rannoch.
Loch Eighiach	818·2	63·42	·09	250	5,000	At Loch Rannoch.
Loch Garry	1,320	22·34	·61	800	6,000	At Struan.
Loch Rannoch	668	243·57	7·37	200	*(1,500)	At Loch Tummel.
Loch Iubhair	512	44·61	·21	150	2,300	Killin Loch Tay.
Loch Earn	317	54·68	3·91	100	1,800	Comrie.
Loch Tummel	454	306·06	·98	140	*(1,300)	Pitlochry.
Loch Freuchie	867·5	23·20	·54	650	5,000	Dunkeld.
Loch Lintrathen	674·6	28·87	·62	300	2,900	Near Alyth.
Dee—						
Loch Muick	1,308	14·28	·85	550	2,700	At Ballater.
Loch Davan and Kinord	550	14·17	·52	120	560	At Aboyne.
Loch of Skene	274·8	17·26	·46	120	690	At Culter.
Orkney—						
Loch Broadhouse	50·85	13·59	·89	50	200	—

* From river flow.

Name of Loch.	Height above sea.	Drainage Area.	Area of Loch.	Fall utilised.	Horse-power.	Point of Development.
	feet.	sq. miles.	feet.	feet.		
Shetland—						
Loch [illegible]oer	349·40	2·23	·15	340	250	Yell Sound.
Loch [illegible]irka	400	2·96	·05	400	400	West of Island.
Loch [illegible]urga	115·65	2·18	·12	110	80	Wall's Bay.
Lewis—						
Loch À Chlachain . . .	211·6	11·92	·07	200	800	Stornoway.
Loch Langavat . . .	108	27·59	3·45	100	900	Loch Roag.
Loch Craobhaig . . .	199·40	5·92	·20	200	400	Loch Hamanaway.
Skye—						
Loch Duagrich	300 (?)	12·5	—	300	1,250	Carbost, Loch Snizort.
Loch Hounan	300 (?)	2·3	—	—	200	" " "
Loch Leathan	438	5	—	420	700	
Loch Luiravay	475 (?)	3·7	—	475	580	Invertote, Sound of Rassay.
Loch Dhugaill	400 (?)	1·75	—	400	200	Tarskavaig Bay.
Loch Na Saile	700 (?)	·6	—	700	120	Kyle Akin.
Loch Lannachan . . .	500	·6	—	500	100	Broadford.
					371,910	
				(Say	375,000)	

The Clyde, Forth, and Tweed Basins have not been dealt with owing to the important water-supply and other interests already involved, nor have the power possibilities of rivers and small streams been included.

By diversion and linking-up of adjoining catchment areas, and impounding beyond the extent provided for in the foregoing estimate, it may be assumed that for, say, 100 days' supply, 650,000 horse-power is available.

Approximate formula for calculating horse-power as above is $\frac{AH}{3}$, where A = catchment area in square miles and H = fall utilised in feet.

A. NEWLANDS, M.Inst.C.E.

January, 1918.

DISCUSSION.

Mr. C. S. Meik, M.Inst.C.E., in opening the discussion, said the paper was exceedingly valuable, and he hoped it would serve to encourage the development of water power in Scotland. He did not think the author had been quite right in giving an average rainfall of 42 inches for the whole of Scotland. In the eastern part of the Highlands 42 inches of rainfall was high, and one could not rely upon obtaining it, but that figure was very low indeed for the western shores of Scotland. There were districts, for instance, west of the Caledonian Canal, where the average rainfall was over 100 inches, and at Kinlochleven, farther south, it was 86 inches. It therefore followed that the water power available on the western coast would be very much more than in the interior. The author apparently favoured the development of small powers, but personally he did not see how small powers could be developed to advantage, especially inland, unless the power was going to be transmitted to a town, and that involved larger stations so that the power could be generated at one station and transmitted in one line. On the western shores of Scotland he thought there was every possibility of large developments in the future, because the use of power to any extent involved the conveyance of raw materials, and those materials could be conveyed much more cheaply by sea than by railway or any other means. It must not be forgotten, however, that where coal could be obtained at as low a price as 4*s*. or 5*s*. per ton for the production of power—as was the case in certain districts in pre-war times—there was not much margin in favour of water, and the additional advantage of the large population present in a coal-mining district was always an attraction to manufacturers to establish their works there.

Mr. W. Murray Morrison, M.Inst.C.E., heartily endorsed the author's suggestion that the authorities should collect information with regard to rainfall records, water power, and similar matters. In certain Continental countries, such as Norway and Sweden, full information on such subjects could be purchased. He did not agree with the remark made by Mr. Meik with regard to small powers, but thought there were a number of industries which might very well be set up to utilise smaller powers, by which he meant 3,000, 4,000, and 5,000 h.p. On the other hand, there were, of course, certain industries which could not be carried on without a very large amount of power, as, for instance, the manufacture of aluminium. With regard to the employment of labour, as a Highlander it was his proud boast that he had been associated with the establishment of two water power installations in the Highlands of Scotland, where the people employed were chiefly crofters. He believed that the establishment of such installations in the

Highlands of Scotland was the key to the situation which politicians had been striving to find for many years past, because it would lead to an increase in agriculture, fishing, and other industries, including afforestation, which would need serious attention after the war. He did not agree with the author's plea for the nationalisation of the water powers in this country. If the Government were to establish industries in the north of Scotland and work them themselves, progress would certainly be hindered; whereas if private manufacturers were encouraged to extend the use of water power, progress would be found to be very much more rapid. If good and up-to-date houses were provided for the workpeople in those parts of the Highlands where water power was capable of development, labour would be attracted to those places, and the workpeople would be much more comfortable and happy than they would be in the more densely populated districts.

Sir John Benton, K.C.I.E., M.Inst.C.E., thought the Government should make a thorough hydrographic survey of all the waterways in Scotland, because at the present time neither the Government nor the users of power knew much about the matter. Owing to the lack of coal north of the Forth, the Highlands of Scotland were dependent to a great extent upon water power; they had an abundant rainfall which would yield a large amount of horse-power, which should be used to develop industries in those districts. Canada, the United States, and many other countries, had had surveys made of their water powers, but this country had, up to the present, done nothing in that direction. Objection might be taken to nationalisation, but a proper survey of the water powers of this country must be regarded as a national question.

Major-General Sir George Scott Moncrieff, K.C.B., C.I.E., had listened to the paper with the deepest interest, and thought that, although the development of water powers might be left largely to private enterprise, there should be some coordinating influence exercised by the Government to see that the utilisation of those water powers was undertaken on some regular and definite plan. The remarks Sir John Benton had just made about the desirability of a careful statistical examination of the country's resources in regard to water power being made seemed to be a step towards that plan. Any application of those resources should be subject to some central control. The very interesting series of lantern-slides indicated the enormous amount of water power that was being wasted at the present time, and he trusted the matter would not be allowed to drop either by the Government or by the great industrial concerns in the country.

The Chairman (Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.) then proposed a vote of thanks to the author for his interesting paper. In doing so, he said that the Census of Production taken in 1907 showed that in Great Britain at that time 10½ million h.p. was being used in stationary engines of various kinds for the industries of the country, which amounted to a little over 1 h.p. per worker. In the United States of America, in a Census of Production taken two years later, in 1909, the total horse-power used in a similar way was over 23 million, showing that the Americans had developed the use of power to a very large extent. He was interested to learn that in Canada the total consumption of power was greater per head of the workpeople than it was in Great Britain, and he supposed that must have come about since the recent development of water power in Canada. The Conjoint Board of Scientific Societies had been taking an interest in the water power of the British Empire, and a committee had been formed, of which Mr. Newlands was a member, to study the whole question. The committee was trying to obtain information as to the water power of Canada, New Zealand, Australia, India, and South Africa, and had already made some progress in obtaining data from those countries. There was no doubt that within the British Empire there was a very large amount of water power. The largest water power in existence, however, was that of the United States, which had a possible 30,000,000 h.p. That meant that if the United States wanted to displace the use of fuel altogether, or if, after five hundred or six hundred years, fuel became very scarce, they could carry on their industries by the use of water power. The author had estimated the water power of Canada as 17,000,000 h.p., whereas the estimate he (the Chairman) had given at a meeting of the Royal Society's committee to which he referred, was about 11,000,000 h.p., but he thought the author's estimate was very likely the more correct one. The water power available in New Zealand appeared to be about 7,000,000 or 8,000,000 h.p., and even Australia had a greater water power than this country. It did not seem possible, judging by the author's figures, that in England steam power and other engine power could be replaced by water power to any very great extent, but it was necessary in the interests of the future of Great Britain that coal should be economised as much as possible, and that every available means, including the use of water power, should be adopted in order to lengthen the industrial life of Great Britain. If that was not done, our industrial life might come to an end in perhaps about four hundred years. The transition of this country from an agricultural to a manufacturing State, which might be called the industrial revolution, began in the middle of the eighteenth century, and if our coal supply came to an end the industrial stage might terminate about five hundred years hence; and, unless we could obtain other means of getting motive power, a very great rearrangement of the British Empire would be brought about, although Great Britain would still, he hoped, be the centre of the Empire. A

hundred years ago, in the last great war, the population of Great Britain and Ireland was only 15,000,000, now it was about 46,000,000; and if this country became once again an agricultural State that population could not be maintained.

MR. ALEXANDER ROSS (Past-President of the Institution of Civil Engineers), in seconding the motion, said the paper contained a great deal of useful information that could be put to a practical use, and he hoped the Government would see that the water power of the country was utilised in a proper manner for the good of the whole nation

The resolution having been carried, MR. NEWLANDS said he agreed with the remarks that had been made as to the desirability of having a hydrostatic survey of the water power of the country. Mr. Morrison was mistaken in thinking that he advocated nationalisation of water power or anything else; he simply wanted it under proper control. Without some Government assistance the development of water power could not make much progress.

OBITUARY.

RUTH MORRISH DAY.—Many Fellows of the Society will receive with much regret the news of the death of Miss Ruth Day, who has contributed to the *Journal* the clever articles on "Arts and Crafts" which have appeared for the past twelve years in its columns. The first of these was published on March 16th, 1906, and the last on December 21st of last year. Shortly after that date Miss Day was attacked by influenza, followed by pneumonia, which caused her death on the 14th inst.

She was the only child of the late Lewis Foreman Day, the well-known decorative artist and designer, who, up to the time of his death in 1910, was intimately associated with the Society as a member of its Council, and a frequent lecturer. After his death she herself joined the Society (1910). In her youth Ruth Day was associated with her father in much of his work, and acted as his secretary, assisting him in the revision of several of his well-known books on art-workmanship. After his death, she continued similar work on her own account, writing on subjects of applied art in other newspapers and periodicals as well as in the Society's *Journal*. When the war broke out she was engaged on the preparation of a book on old Initials for Messrs. Batsford, the publishers, but the issue of this work was postponed. She succeeded her father as a member of the Committee of the School of Art Woodcarving, and took an active part in its management, interesting herself in the welfare and progress of many of the younger students.

During the last few years of her life she devoted a great deal of her time to mission work in connection with the Church of England. She was an earnest student of theology, and obtained the Archbishop's diploma in that subject, as well as a certificate as teacher. Perhaps her religious work as a lecturer and teacher was really nearer her heart than the artistic pursuits to which she had been trained, considerable as was her capacity for the latter. However, she had made a distinct reputation as a writer on applied art, and had not her promising career been cut short at so early an age—she was a year or two short of forty—she would doubtless have produced more work of permanent value and importance.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JANUARY 28...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. C. R. Darling, "High Temperature Processes and Products." (Lecture II.)

Geographical Society, Central Hall, Westminster, S.W., 8.30 p.m. General Smuts, "East Africa."

TUESDAY, JANUARY 29...Royal Institution, Albemarle-street, W., 3 p.m. Professor W. M. Flinders Petrie, "Palestine and Mesopotamia: Discovery, Past and Future." (Lecture III.)

Electrical Engineers, Institution of (Local Section), 17, Albert-square, Manchester, 7 p.m. Mr. F. G. C. Baldwin, "Telephone Exchange Transfers and their Organisation."

WEDNESDAY, JANUARY 30...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Sir William George Watson, "The Manufacture of Margarine in Great Britain."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Dr. G. E. Smith, "The Reform of the Treatment of Mental Disorders."

THURSDAY, JANUARY 31...Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Napier Shaw, "Illusions of the Atmosphere; Revolving Fluid and the Weather Map." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Lecture by Dr. C. Atkin Swan.

FRIDAY, FEBRUARY 1...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor A. S. Eddington, "Gravitation and the Principle of Relativity."

University of London, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture III.)

SATURDAY, FEBRUARY 2... Royal Institution, Albemarle-street, W., 3 p.m. Mr. M. P. H. Loyson, "The Ethics of the War." (Lecture I.)

Correction. — The name of Mr. Charles H. Challen, who took part in the discussion on Dr. Clay's paper on "The British Pianoforte Industry" (*Journal* of January 18th, p. 163, column 1), was incorrectly given as Mr. John D. Challen.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

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FRIDAY, FEBRUARY 1, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 4th, at 4.30 p.m. (Cantor Lecture.) CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." (Lecture III.)

TUESDAY, FEBRUARY 5th, at 4.30 p.m. (Colonial Section.) C. DU PLESSIS CHIAPPINI, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa." The RIGHT HON. VISCOUNT GLADSTONE, G.C.B., G.C.M.G., G.B.E., will preside.

WEDNESDAY, FEBRUARY 6th, at 4.30 p.m. (Ordinary Meeting.) WILLIAM FRECHEVILLE, A.R.S.M., F.G.S., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of the Mineral Resources of the British Empire." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., Member of the Council of the Society, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

JOURNAL.

Owing to the enormously increased cost of printing and paper, it has been found absolutely necessary to discontinue the issue of double numbers of the *Journal*. Reports of the Ordinary Meetings and meetings of the Indian and Colonial Sections will be given, one each week, in chronological order. It is much regretted that a break should be made in the custom of publishing the reports of the Wednesday meetings on the following Fridays, which has been maintained since the foundation of the *Journal* in 1852.

This change is only a temporary war measure, due entirely to the necessity for retrenchment in every possible direction, and it is intended to revert to the former practice of prompt publication as soon as circumstances permit.

The report of the Eighth Ordinary Meeting, on January 30th, when a paper on "The Manufacture of Margarine in Great Britain" was read by Sir William George Watson, Bt., will be published in the next issue of the *Journal*.

CANTOR LECTURE.

On Monday afternoon, January 28th, Mr. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, delivered the second lecture of his course on "High Temperature Processes and Products."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, January 17th, 1918; The RIGHT HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., in the chair.

THE SECRETARY of the Section announced that Lord Sydenham, who had promised to preside, could not attend, as a Bill to which he had amendments was coming on at the same hour in the House of Lords. The following letter had been received from him:—

101, Onslow Square, S.W.,
January 16th, 1918.

DEAR SIR,—I deeply regret that I am unable to take the chair to-morrow. From the first, I have taken a warm interest in the great undertakings of the Tata Company. They have shown that steel of the highest class can be made in India on a great scale, and the work that is now being carried on and developed is of the utmost value to India and to the Empire. During the war, the advantages arising from the output of steel have been most important. India will become self-supporting in this respect, and on the basis of Indian steel a large number of other industries will be rapidly

built up. It is not too much to say that Messrs. Tata have given a new impulse to Indian industries, which will have incalculable results in the near future. The hydro-electric installation in the Bombay Presidency is the finest of its kind in the world, and it has proved what Indian capital can accomplish under wise and sound direction. What India needs most at the present time is industrial leaders like the Tata family, who, by their enterprise and the confidence they inspire, can turn to account the immense resources of the country and spread prosperity far and wide among the people.

I am, yours faithfully,

SYDENHAM.

The paper read was—

THE TATA IRON AND STEEL WORKS: THEIR ORIGIN AND DEVELOPMENT.

By H. M. SURTEES TUCKWELL, M.I.Mech.E.

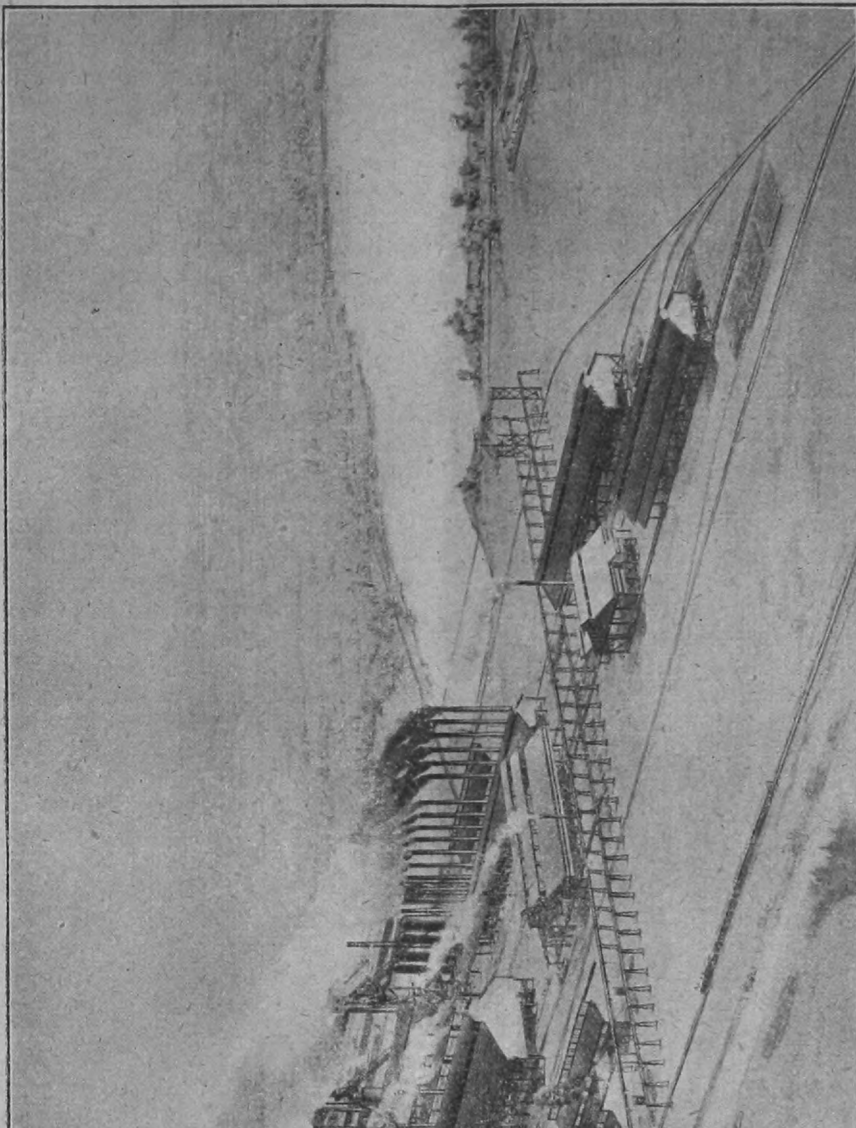
I should first express my very high appreciation of the honour your Council has done me in inviting me to read a paper before you, and, by recording my sense of unworthiness, to secure a measure of your sympathy and indulgence in the shortcomings of my effort to interest you this afternoon—shortcomings of which no one is more conscious than myself.

The main lines which I desire to traverse in this paper are the Tata Iron and Steel Company, its origin and development, and the effect which it will have upon the industrial prosperity of India.

It is supposed that ancient India acquired the art of smelting and forging iron from the Chinese. It is, at any rate, certain that in the early ages Indian artificers possessed, to a high degree, skill in smelting and fabrication of metals. This is witnessed in the wonderful workmanship of ancient weapons still found in India, and the 3,000-year-old iron pillar of the Kutab-minar near Delhi, the methods employed in the construction of which are unsolved by metallurgists of to-day. In the Middle Ages the craftsman's dexterity was still maintained, and India supplied the materials from which the famous Damascus steel blades were made. The industry flourished till the downfall of Sikh independence in the last century, chiefly for the manufacture of swords and armour. Progress was extremely slow, and to this day the most primitive methods of smelting are found among the jungle dwellers.

The first attempts to establish an iron and steel industry on Western lines in India were made by Mr. Joseph Marshall Heath, a retired Madras civilian and a friend of Charles Dickens, who obtained a grant from the directors of the East India Company and established works at Porto Novo, on the Madras coast, in 1830. The expenses of buildings and experiments exhausted his funds, and the Government gave him a loan of 5¾ lacs of rupees, of which his debts absorbed 4¾ lacs. He had installed furnaces capable of producing forty tons of pig-iron weekly, and his intention was to manufacture bar iron and export to England in competition with Swedish iron. He was faced by numerous difficulties. His boiler burst, and the blowing engines had to be driven by bullocks. His operators lacked practical experience; his limited capital hampered him; the quality of the ore varied; and the supply of charcoal used for the reduction of the ore was insufficient. It may here be noted that up to that time all iron smelters in India utilised charcoal as fuel. It is recorded that in Mr. Heath's furnace 3¾ tons of charcoal were required per ton of iron. In the latest American practice, which, we believe, can be realised in India, one ton of pig is produced with one ton of charcoal. His costs amounted to Rs. 45 for smelting one ton of ore. In 1837 he sought a fresh loan from the Government, who refused. Poor Mr. Heath, penniless and broken in health, died, and in 1853 a new company, the East India Iron Company, took over the undertaking, which, however, stopped altogether in 1874.

The second attempt was in 1875, when the Barakar Iron Works Company started on the Jherria coalfields, 143 miles north-west of Calcutta. They likewise failed, and closed in the same year. The Government restarted operations in 1881, and in 1889 made over the concern to the Bengal Iron and Steel Company, who have successfully produced pig-iron ever since. In 1905 the Bengal Iron and Steel Company opened a steel department, but it was found there was not sufficient demand for small steel sections at that time to give continuous rollings of any one section to work economically. As an instance of this, the Government orders for six-months, a total of 180, amounted to less than 1,000 tons and included seventy different sections. Manufacturing under such conditions resulted in a considerable loss of money, and the steel department was closed down in twelve months after starting. The Company, however, has a large output of pot sleepers, cast-iron pipes, and mill columns, and specialises in foundry pig-iron. There is little doubt that the representations made by the Bengal Iron and Steel Company to the Government, although they did not produce the practical support which was hoped for at the time, nevertheless paved



TATA IRON AND STEEL COMPANY, LIMITED, KALIMATI WORKS, BENGAL, INDIA.

the way for the Tata Iron and Steel Company, who have obtained a large measure of support and practical assistance from the Indian Government.

The third attempt was that of the Tata Iron and Steel Company, which was formed in 1907.

It would be remiss in dealing with the origin of this Company to pass on without a brief sketch of the life of the founder, Mr. Jamsetji Nusservanji Tata, who was born at Navsari, in Baroda State, in 1839. His parents belonged to the priestly caste of the Parsee community, and his biographer records that the small town of Navsari was a stronghold of the Zoroastrian priesthood, whose two principal characteristics were doggedness and perseverance. Such an atmosphere contributed in no small measure to the formation of Mr. Tata's character, and the acquirement of these attributes enabled him to realise his ambitions in the face of obstacles, insurmountable to a man of less determination.

At thirteen years he was sent to the Elphinstone College at Bombay, where he studied for six years. His commercial training was obtained in his father's Bombay office, and in a Hong-Kong office. Subsequently, after visiting Manchester, and there studying textile manufacture, he established a cotton-mill at Nagpur. A good many initial difficulties had to be surmounted, but Mr. Tata was eventually rewarded by unprecedented success, and the Company had, up to the end of 1913, made a present to their shareholders of $2\frac{1}{8}$ shares per share held. New mills and other enterprises followed, and after 1895 he resolved to realise the three great ambitions of his life, which he had been revolving in his mind for twenty years. These were: (1) the smelting and conversion into steel of the iron ore known to exist in large quantities in India; (2) storage and utilisation for industrial purposes of the immense monsoon waters which fall annually on the summit of the Western Ghats; (3) institution of a scientific research laboratory, whose investigations should foster and develop the innumerable Indian resources hitherto imperfectly explored.

Mr. Tata had first obtained a concession to work the Lokara ore with Warora coal; this coal proved unsuitable for coking, and he relinquished the scheme. In 1899 Lord Curzon introduced new rules for mining and prospecting, which materially facilitated industrial development, and at the end of the last century Mr. Tata visited England, saw the Secretary of State for India (Lord George Hamilton), who gave him considerable encouragement and promised Government help. On his return to India Mr. Tata obtained permission to work the Chanda iron ore deposits. In 1902 he visited America, obtained expert advice, and, amongst others, saw Mr. Julian Kennedy, and engaged Mr. C. P. Perin, a noted New York mining engineer, whose associate, Mr. C. M. Weld, left for India shortly afterwards.

At this time Mr. Tata associated with himself in the concession his son, Sir Dorabji Tata. Prospecting was now actively in operation. Mr. Tata's speculation amounted to £35,000, which was sunk in preliminary expenses before the Company was floated, a good deal of this sum representing the cost of flotation. The preliminary investigations were necessarily protracted, as when ore deposits were located much expert analysis was needed to determine the economic possibilities of smelting the ore, and, this point having been established, ascertain the availability of suitable coal within reasonable distance. Many properties were investigated and relinquished. Eventually Mr. Weld located a deposit of one of the richest iron ores in the world, the Rajara Hills, Central Provinces, which are practically solid iron, and the Dhullee Hill near by, which also provides a very rich ore. A prospecting licence was secured, and diamond drilling revealed an ore yielding about 66 per cent. pure iron. Finally, through Mr. Perin's and Mr. Weld's investigations, the deposits at Gurumaishini in Mourbhanj were found to offer the most favourable conditions for immediate operation, these being materially influenced by the proximity of the Jherria coalfields. Prospecting and mining leases were obtained from the Maharaja of Mourbhanj, conditionally upon the total area taken up not exceeding twenty miles. Prospecting continued till 1909, when a thirty years' mining lease with option for renewal for a smilar period was obtained by the Tata Iron and Steel Company. Government sanction was secured in 1910, and the Tata firm now had concessions for Gurumaishini and other iron ores in Mourbhanj, Dhullee, Rajara and Chanda iron ore in Central Provinces, acquiring also their own manganese mines at Ramramah, Central Provinces. Samples of coal from different seams in the Jherria coalfields were sent to America and Europe for analysis and coking test, and it was found that while they contained a high percentage of ash, they yielded sufficiently hard coke for blast furnace purposes, nor was the high ash an objectionable feature when reducing a rich ore like the Gurumaishini ore, as it helped to form a slag. Limestone of

excellent quality at Jukehi near Katni, and dolomite at Panposh, were secured.

The result of expert investigations in Europe and America were carefully studied with a view to determining how far Western practice might be adopted in India. The information thus obtained was devoted to the establishment of a research laboratory at Bangalore, endowed by Mr. Tata with 30 lacs, or £200,000. The site was given by the Maharaja of Mysore, and further financial assistance by the Government of India. The equipment was to include: (1) Scientific and technical; (2) medical; and (3) philosophical and educational laboratories, together with libraries, museum and other essential factors, and in 1911 actual work commenced. Fate decreed that the originator of the scheme should not live to realise the ambitions of his life. Dryden has said, "Pioneers from Moses onward, see yet cannot achieve their aims, but they make God's kingdom possible," and often, as in this case, their successors carry on their work. Mr. Tata's two sons and his cousin and partner, Mr. R. D. Tata, assumed the mission which had survived its founder, and their determined energy and whole-hearted co-operation have been rewarded by the consummation of Mr. Tata's three ideals. To-day the research laboratory, after a chequered period of constructional and preliminary difficulties, is now in full operation, and, according to Mr. Chatterton, Director of Industry in Mysore, the work of that institute in 1915–16 has in its industrial results more than repaid to India the whole of the outlay expended upon it. The monsoon's rains are compelled to drive fourteen cotton-mills of Bombay, and the Tata Iron and Steel Company during 1916 produced 187,000 tons of pig-iron and 125,000 tons of steel.

The Tata Iron and Steel Company, Ltd.

When, some years before the steel company was established, their consulting engineer met in conference a number of railway magnates and experts, he was told that steel rails could never be made in India from indigenous materials. As an instance of their failure properly to assess the situation, I may remark that a large tonnage of rails has for a year and a half been shipped regularly to Mesopotamia, and other theatres of war, and played no mean part in the relief of Baghdad.

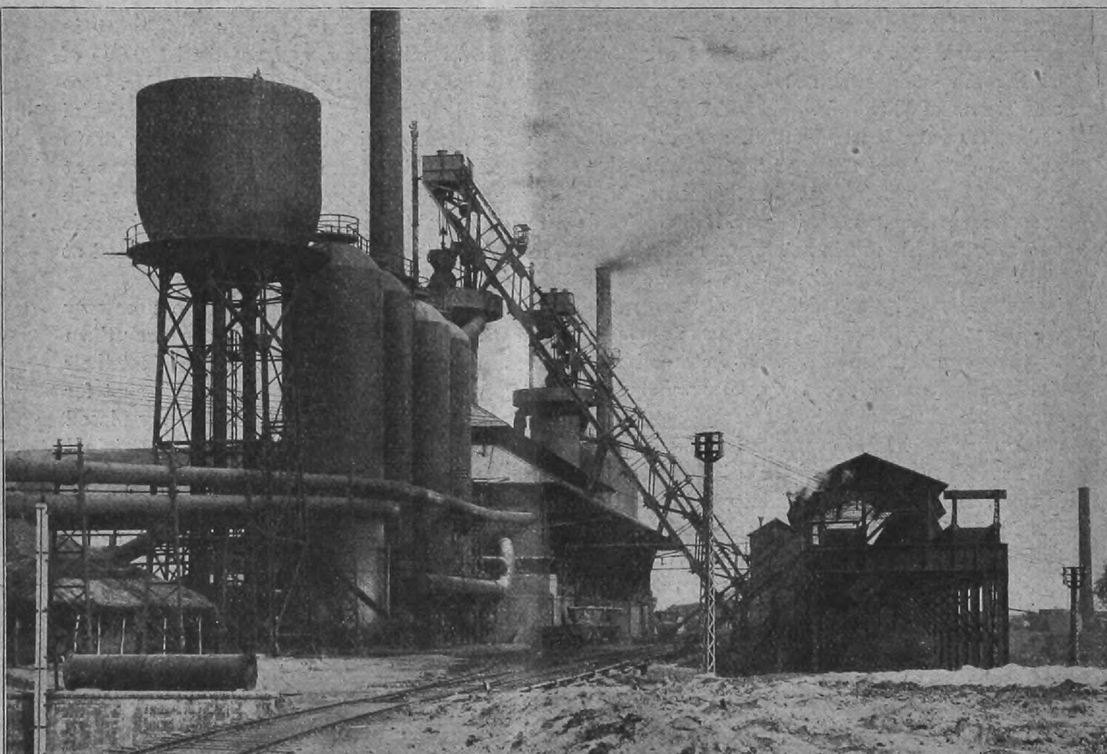
Prior to the geological survey of India, very little was known of the metalliferous resources of that country. Valuable assistance was rendered by Lord George Hamilton, Lord Curzon, Sir John Hewett (Member of Council), Mr. Harvey (Secretary of Government), and Sir Thomas Holland. To the latter gentleman, as an expert, the entire Tata scheme was referred, and he appears to have made a wholehearted commendation of the American experts' report to the Tatas.

In 1907 the Tata Iron and Steel Company was formed, with a capital of Rs. 2,31,75,000 (£1,545,000). The Dhullee-Rajara ore deposits had been discovered by Mr. Bose, an Imperial geologist, and, as before mentioned, Mr. Tata's private survey had proved them. The same gentleman, after resigning the Imperial service, became the private geologist of the Maharaja of Mourbhanj, who took a great interest in Mr. Tata's enterprises, and acquired £20,000 of shares in the company when formed. Mr. Bose had lately discovered iron ores at Gurumaishini in the Mourbhanj State, and the Maharaja invited the Tata firm to smelt these ores at Gurumaishini. Geographical conditions made this undesirable, but the firm were glad to acquire mining rights for the ores which are smelted at Sakchi.

The initial stages of locating the necessary raw materials and securing rights to work them were now completed, and the explorers set their attention to the selection of a suitable spot for their assembly, which might be centrally placed in regard to the various supplies. Original intentions favoured Sini, a junction on the Bengal-Nagpur Railway, in the Singbhum district, but the construction of an essential in the shape of a reservoir, estimated at from Rs. 15–18 lacs, made further search desirable, and eventually a site near Kalimati Station, eighty miles east of Sini Junction, was selected early in 1908. Here, on a territory more or less covered with jungle, populated by a few scattered Santali people, probably the most interesting undertaking in the history of industrial India was initiated. A small Indian village known as Sakchi has given its name to the works and township, which in magnitude may ere long rival many a Western steelworks.

When the Steel Company was formed, twenty square miles were obtained on lease for a number of years, and of this property about five square miles were originally acquired through the Land Acquisition Act in perpetual ownership. Since that time further acquisitions have been considered and are now in process of being made. The Government had given necessary mining concessions, and the Bengal-Nagpur Railway promised reduced freights for construction

material and plant, and the assembly of raw materials. The Indian Railway Board, as a mark of sympathy and goodwill, had placed an order for ten years' annual supply of 20,000 tons of steel rails, the conditions being that the rails must comply with Government specification, and the price be no more than similar goods delivered c.i.f. Indian ports. They further constructed forty miles of line connecting Kalimati with the Gurumaishini ore mines, and made special valuable concession freight rates dependent on certain ton mileages covered per year. The local Government also greatly south the estate is bounded by the Bengal-Nagpur Railway, whence raw and finished materials are transported. On the east is a range of rocky hills, from 500 ft. to 3,500 ft. in height, on the summit of which it is proposed to create a sanatorium and hill station. Here the vigorous may obtain a week-end of rest and enjoy somewhat cooler conditions, and the sick or convalescent recover without the fatigue and expense of a journey to Simla or other established stations. The health conditions at Sakchi are excellent. The station is 532 ft. above sea-level, with a natural drainage on each side.



BLAST FURNAECS.

assisted the Company in securing land grants and avoiding administrative delay.

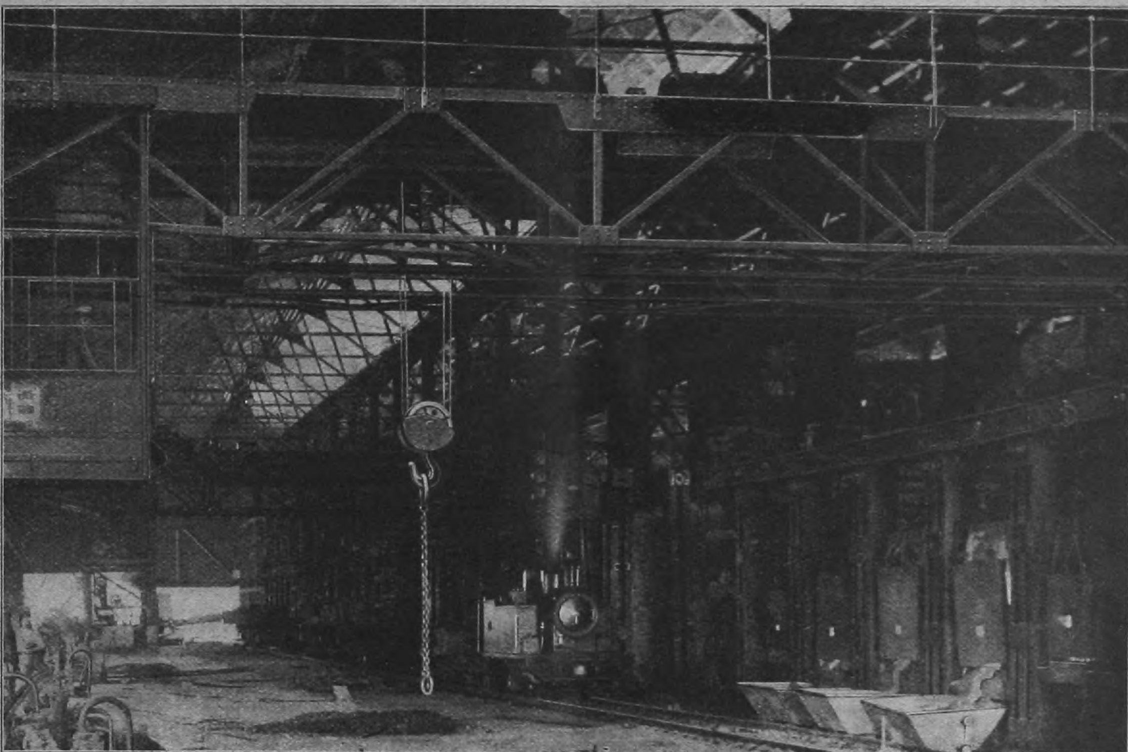
The works lie 150 miles west of Calcutta, 40 miles from the Gurumaishini iron ore mines, and 115 miles from the Jherria coalfields, and the careful judgment of the firm's consultants provided that the works should be bounded on the north by the Subnareka River, and the west by the Khorkai River. The former had never been known to run dry in the hottest summers, and thus afforded ample water-supply, a most necessary feature in a steelworks. On the The climate is healthy and dry, and though the temperature reaches 118° F. in the shade during hot weather, it is not unbearable. Surface drainage is very satisfactory all over the property. At a depth of from 4 ft. to 5 ft. is found a stratum of mica schist, forming an efficient foundation for heavy machinery. At the time of which we speak land was not costly to acquire, and had little agricultural value.

The plant as originally erected consisted of two blast furnaces, designed for 175 tons per day, or 120,000 tons per annum; four Siemens-

Martin open-hearth furnaces, with an output of 85,000 tons ingots per annum; blooming mill; rail and beam mill; two bar mills; 180 Coppee non-recovery coke ovens—the total output of finished steel being 72,000 tons per annum. A study of statistical reports shows that before the Tata Iron and Steel Company began operations, India's contribution to the total world production of iron and steel was practically negligible, and in 1906 amounted to only one two-thousandth part of the annual world production of pig-iron, while for steel she had to entirely depend on foreign countries.

labour; ample supplies of rich ore and raw materials, were the most obvious of these; but, on the other hand, we must not forget the previous disastrous attempts to make steel; the unknown effects of climatic conditions; the untrained and physically inefficient native labour; the excessive cost of imported labour; and the experts' expressed opinion that steel rails could never be made in India.

In February, 1908, camps were formed near the old village of Sakchi, and the work of jungle-clearing began in a district where wild beasts had hitherto roamed at will. Hundreds of



STEELWORKS.

The Indian railways demanded an ever-increasing supply, and collieries, cotton and jute mills, were becoming an important market for western exporters. Here, then, was an opportunity possessing many of the elements essential to success, and only awaiting the courage and determination of a pioneer.

In India, Burma, and the Far East, the manufacturer had unquestionable advantages over foreign competitors. Elimination of freight charges; cost of mining and transportation the lowest in the world; an abundance of cheap

bullock and buffalo carts arrived and transported rails, sleepers, bricks, cement, and other construction materials from Kalimati, and assembled them in huge piles on the works' site. Arrangements were made for a water-supply from the Subnareka River, buildings sprang up, and, by the end of the year 1908, several of these were completed. A most important adjunct was the construction of a macadamised road from Kalimati station to the works and a broad-gauge railway, three miles long. By August, 1909, this was open for traffic, and

proved invaluable for transport of heavy machinery and stores. The diminutive station at Kalimati was now rebuilt, and a large goods yard added.

In 1910 the waterworks were completed, a pick-up weir was thrown across the river, a pumping station with a capacity of one million gallons per twenty-four hours erected on the river bank, and a 28-in. pipe-line laid up to the works, a distance of 9,000 ft. Some five acres of suitable ground were selected, a dam constructed to form a bund or reservoir, in which the water might be stored for works and domestic use. The town included bungalows fitted with electric light, fans, and water service; cottages, coolie lines, institute, court house, police-station, and hospital. A soda-water factory and ice plant were provided, as the drinking of unsterilised water is attended by considerable risk.

Machinery began to arrive in 1910, and the coke ovens (foundations for which were begun in the latter part of 1909), were fired for the first time on October 12th, 1911. On November 2nd, 1911, the first or "A" blast furnace was blown in, and "B" furnace on September 25th, 1912 Early in the same year the steelworks began operation, and the first piece of ingot steel was rolled on the blooming mill on February 16th, 1912, while a month later the first rails were produced, being followed in October by the bar mills producing flats, squares, and rounds. Up to this time 31,000,000 cubic feet of brick, masonry, and concrete, 7,000,000 firebricks, and 24,000 tons of structural steel, machinery, boilers, etc., had been worked into place. To effect this, 5,426 waggons had been brought over the lines to Kalimati in 1911, and 15,800 waggons in 1912. Happily anxiety in regard to the supply of labour was not realised, and about 4,000 Indians were employed during the construction period. Many difficulties were experienced and surmounted, as one department after another was started up. This being the first time that the manufacture of steel under modern conditions had been undertaken in India, absence of previous experience of working under tropical conditions, and employment of entirely unaccustomed labour were excuse for failure to attain results achievable under Western conditions.

In the initial stage there was much alteration, pulling down, and reconstruction. Steel output fell far short of standard, and transient labour imported from Germany handicapped the efforts of the management. Perseverance and courage on the part of the firm, the staff, and their expert advisers, eventually triumphed, and the preliminary period was educational for the workers and enabled the management gradually to reduce the percentage of European or American employees and substitute Indian labour. To-day in the bar mill three eight-hour shifts, which would require the employment of twenty-seven Europeans, are manned by a crew of twenty-five Indians who run the plant economically with only two European superintendents, and in other departments similar reductions have been made. The chemical laboratory originally employed five European chemists. Now the chief and assistant are Europeans, the remainder of the staff of twenty-one being Indians. In addition to the works laboratory there is a Government laboratory, under the charge of Dr. M'William, resident Government Inspector, and formerly of Sheffield University; also a physical laboratory equipped with 100-ton Buckton testing machine, and other test apparatus.

In very many instances Indian workmen have shown themselves possessed of extraordinary skill and manual dexterity, and the electrical department is under the superintendence of an Indian gentleman, a graduate of an English university, assisted by a staff of Indian wiremen and electricians.

The coke ovens and blast furnace department gave satisfactory results from the first, and to some extent compensated for the anxiety and losses due to the disappointing results from the steelworks. Then when most of the difficulties had been overcome, the war broke out, and added a new source of apprehension to the management. The open hearth department was being operated by a German crew, and it was necessary to make immediate arrangements for the substitution of an English crew, the Germans being interned at Ahmednagar.

Mr. Perin, to whom reference has already been made, had now taken charge in an advisory capacity. Efforts were maintained to reduce costs of production, and essential additions were made. The 180 Coppee coke ovens proving insufficient, fifty Koppers by-product ovens were ordered in 1914, and began to turn out coke in 1916, the by-product plant being started up shortly after, together with the manufacture of sulphuric acid, for which an equipment with a capacity of 40 tons weekly was erected. Sulphate of ammonia and tar were now added to the sales list of the Steel Company, and materially reduced the manu-

facturing cost of coke, and consequently pig-iron.

The blast furnaces designed for 175 tons per day each, are turning out 280 tons as a result of Mr. Perin's alterations, and the receipt of new and more powerful blowing engines is expected to reduce coke consumption to well below one ton per ton of pig-iron.

A very interesting experiment is shortly to be tried in Mysore. The Government of that State have decided to erect a charcoal blast furnace, and have appointed Mr. Perin as their consulting engineer. He has placed orders for the equipment in America, and the undertaking is to be managed by the Tata Iron and Steel Company. It is proposed to fell and transport timber from the vast forests of Kadur and Shimoga, and convert it into charcoal at Benkipur. Iron ore will be mined at a distance of twenty-five miles, and a high-grade charcoal iron produced. It is also intended that acetate of lime, alcohol and other by-products will be extracted, and calcium carbide may be manufactured, using the breeze or such portions of the charcoal as cannot be used in the blast furnace. The plant will be constructed and run by the Tata Iron and Steel Company.

In 1916 a world shortage of ferro-manganese was experienced, and great difficulty was found in providing the Sakchi furnaces from this country. One blast furnace was accordingly put on to this manufacture, and 3,000 tons were made, of slightly lower manganese content than is used here, but quite valuable for our works purposes, and over 1,000 tons were sold to America. A special foundry had been built for making cast-iron pot sleepers. Blast-furnace slag, which was used for filling purposes or was piled up in unsightly heaps, was being made into granulated slag bricks, more durable than common red brick; also, by adding phosphoric rock to the slag, a valuable fertiliser will be produced.

Silica and magnesite bricks originally imported from Europe were being made locally from indigenous materials, and latest results show that the Company will very soon be altogether independent of outside sources of these supplies, a very important matter, as the consumption for the next three or four years will be at the rate of 40,000 bricks per day. The Company now make their own ingot moulds, rolls both steel and iron, standard templates for rails, and participate in bricks made locally from their own magnesite.

Visitors to the steelworks coming from Bombay usually arrive in the darkness of the small hours. The flames of the blast furnaces and coke ovens are visible for several miles, a striking contrast to the silent blackness of the jungle being traversed. A tour round Sakchi by daylight makes a very favourable impression —wide roads, admirably disposed and planted with trees, airy bungalows each with its garden, many of these radiant with flowers often grown from English seeds. In the centre of the European town is a wide maidan, or common, where games are played, cricket and football being very popular. Indians have quickly adapted themselves to football, which they play with bare feet. The Babus, who generally wear slippers, kick them off when playing, and apparently suffer little inconvenience from the nature of the ground, which is very hard and covered with small stones.

A fine institute faces the maidan, and contains concert hall, billiard rooms, reading rooms, for men and women, while in the adjacent grounds are tennis courts and bowling alley. A company of the Chota-Nagpur Light Horse has been formed, and the firm provided a rifle range and armoury.

Two motor-buses take passengers to and from the works and Kalimati Junction, thus freeing the branch line of passenger traffic.

A church was completed about a year ago, and is entirely constructed of slag bricks. These are composed of a mixture of blast-furnace slag and lime, and merely dried in the sun. They are pleasing in appearance, and said to be more lasting than common brick. Church of England and sectarian services are held. The Bishop of Nagpur pays occasional visits and a missionary spends one Sunday in four. There are many Indian Christians, and attendance at a service specially for Indians, where prayers, hymns and sermon are in Hindustani, is an impressive function.

We have followed the development of the steelworks through its early stages, and reached the period when all departments were operating satisfactorily. During the second year of the war all the steel output of the works was at the disposal of the Government; shell steel was being supplied to Indian munition works, rails to Mesopotamia. The demand for more and more steel had determined the firm considerably to enlarge their manufacturing capacity and the consulting engineer was instructed to draw up a report on a generous scale for extensions. It has been shown that hitherto pig-iron, steel rails up to 100 lb. per yard, joist,

angles, channels, squares and rounds, comprised the total diversity of output. The tonnage of pig-iron and steel corresponded approximately to the Skinningrove or Frodingham Iron and Steel Company of this country.

The report on extensions was submitted in March 1916, and acted upon in the following autumn. War conditions made it very difficult to purchase complete plant, and it was therefore decided to procure machine tools and equip a large machine-tool shop, and manufacture the bulk of the new plant at Sakchi. The consulting engineer secured office accommodation in New York, engaged draftsmen and technical staff, and began the layout of the new works extensions and the design of the various units. These will comprise two blast furnaces of the latest American design, having an output of 600 tons each per day; a well-designed blast furnace has also been bought second-hand, is being pulled down and will very shortly be re-erected at Sakchi, for the manufacture of ferro-manganese. So large a tonnage of pig-iron will require ample coke, and 200 Wilputte coke ovens, each of 13 tons capacity and having a coking time of eighteen hours, are being erected. The annual total coal consumption will be 1¾ million tons. The Company has strengthened its position in the possession of raw materials by the acquisition of new properties in iron ore, coking and gas coals, steam coal, dolomite and limestone. The Company would not be held up by alien ownership of raw materials necessary to its existence and growth, and it may be presumed that the establishment of the Industrial Bank and the projection of a shipyard are due to the realisation that cheap finance and transport are as essential to the life and fulness of industry as raw material.

A greater diversity of products has been arrived at in the extension programme, and there will be made ship and boiler plates; sheets and tinplates; corrugated sheets, for which a very large market exists in India; cast-iron pipes to 24 in. diameter; wire rods and wire; pressed steel sleepers; patent steel piling sections; also a structural shop for bridges, roofs, and buildings; and a waggon factory for railway cars and waggons. In addition to the above articles made by the Steel Company, it is intended to attract a number of subsidiary companies with their manufactories adjacent to the steel-works, and negotiations are in progress with first-class firms, having as an object the manufacture of butt and lapwelded steel tubes; enamel ironware; smelting of zinc; an engineering shop for engines, boilers, and general plant; a shipbuilding yard; an electric repair and construction shop; a manufactory for various chemical industries. A textile plant manufactory may be established if a suitable opportunity offers, and a list of many other industries has been compiled which may be added as the scheme develops. The Steel Company are able to offer many attractions to such subsidiary companies as may be associated with them—cheap land, electric power and light, coal, coke, gas, railway facilities, advice and assistance in the layout and construction of their works, necessary housing accommodation for their employees. Pig-iron and steel will be drawn from the Tata Company in whatever form best suits the user.

To provide ample materials for all the above purposes it has been decided to add the following plant (orders for essential details were placed in America, the resources of this country being entirely devoted to war purposes, while the rolling-mill housings, castings, and bulk of the heavy components are now being made in the workshops at Sakchi):—Blooming mill; Morgan continuous sheet bar and billet mill; Morgan continuous merchant mill; plate mill; wire-rod mill; sheet mill; second rail mill; pig-casting machine; steel sleeper presses; cast-iron pipe foundry; bolt, nut, and rivet works.

The four Siemens-Martin 40-ton open-hearth furnaces have been enlarged to 50-ton, and two new 50-ton open-hearth furnaces added during 1917, enabling an output of 18,000 tons per month to be maintained.

These will be further supplemented by a duplex process of steel manufacture, which very materially reduces the time of conversion. Molten pig-iron will be carried in ladles and stored in a 3,000-ton mixer, from thence 20 tons at a time will be transferred to a Bessemer converter and blown for twenty minutes, during which time the silicon will be eliminated. This blown metal will be conveyed to a tilting furnace, and after some three hours will have been converted into steel conforming to the desired analysis. It is then tapped and cast into ingot moulds of latest improved type, and the moulds removed to an open-air stripping ground, where the heat given off will disperse with least inconvenience to the workers.

Three 6-ton electric furnaces will produc refined steel suitable for springs, tool steel, etc., or may be devoted, should occasion demand, to making ferro alloys.

Ingots will be 24 in. by 24 in. for all except

plate mill, for which special slab ingots are to be cast, thus reducing much of the preliminary blooming and rolling. A large range of soaking pits will receive the ingots and effect a uniform distribution of heat throughout the body of the ingots before they enter the cogging mill. From thence the ingot is transferred to an electric tilting chair, which deposits it on the roller tables, which in their turn pass it to the cogging mill.

To operate all these additions it has been necessary largely to augment the power plant. Twenty 500-h.p. Wickes boilers, arranged to be fired with blast-furnace gas, are in course of delivery, a second large power-house will receive one 5,000 and one 3,000 kw. high-pressure turbo-generators, and a 2,000 h.p. mixed pressure generator, steam for the latter being principally obtained from the exhaust of the three existing rolling mill engines. Drive for the remaining rolling mills will be by electric motors. Power will be generated at a pressure of 10,000 volts, and reduced at two transformer stations, placed in convenient positions in the works.

Some twenty-five cranes have been ordered, ranging from 120-ton ladle cranes to 10-ton shop cranes.

An important addition will be a new works office building at Sakchi, at an estimated cost of £38,000. This will have seven storeys, and be constructed on the American principle, the skeleton of the building being composed of Tata steel sections, on which the floors and walls are carried, and outside the main walls broad verandahs will afford shade to the rooms. Lifts at three of the four corners will provide access to all parts of the structure, and a system of washed and cooled air will ensure ventilation throughout the building, an intake for the air being formed in the fourth corner.

The handling and transportation of the large quantities of raw and finished material demands special study, and our consultant has evolved a system of tracks, which, while to his expert mind falling short of the ideal, due to the difficulty of its inclusion in the original layout, still presents a simple and economical solution to the railway facilities, and in eliminating congestion in shunting operations is conducive to reduction of costs in this important and often neglected department. Five locomotives are on order to supplement the five now operating the traffic of the works, and a number of additional waggons for coal, ore, etc. The necessity for these will be realised when I state that the approximate increase in traffic amounts to 253 million ton miles. The immense difficulties of carrying out all these diverse extensions in war time will be appreciated by those familiar with present conditions in regard to manufacture and export. A number of ships carrying material have been lost, and the replacements occasioned serious delays. It is due to Mr. Perin's genius that we have so far surmounted them, and to his untiring energy that we confidently look for final achievement.

Welfare work will form a substantial feature of the new extension programme, and with this I would now deal. It may be predicated that the standard of Indian unskilled labour is 300 years behind that of Europe, and while in some directions Indian workmen rapidly acquire extraordinary dexterity, they are extremely conservative, their domestic habits, environments, creeds and caste prejudices, forming a serious barrier to the cultivation of Western methods. The question of the elevation and education of the labourers and their families must be approached with great judgment and caution. It is the ambition of the directors to ensure best possible conditions of employment for their workers; healthy dwellings and work-places; skilled medical attention in accident or sickness; supervision of infant and child life; facilities for recreation hitherto unknown to them, to which they take very kindly; adequate pay for their labours; nourishing food at reasonable prices. The last two may be provided through the medium of a co-operative store and co-operative bank, whose activities will encourage thrift and facilitate a scheme for a payment of bonus in addition to weekly wages. This bonus paid into the co-operative bank would enable a credit to be established at the co-operative store for each depositor, who could then secure goods against his credit. It is hoped that the usurious moneylender may be excluded from the station by these means.

Experts like Mr. and Mrs. Sidney Webb, Miss Harrison and Professor Urwick, have been consulted, and it is intended to send a trained welfare worker to Sakchi very shortly, who may assist and advise the management in the organisation of this department.

Among the first institutions at Sakchi was a hospital, fully equipped with modern devices and controlled by an Indian doctor, whose skilful direction during the past eight years leaves nothing to be desired. The number of patients treated during the year ending December 31st, 1916, was 154,857, over 40 per cent. of whom were drawn from a radius of twelve to fifteen miles, representing a population

of 60,000 souls, only half being connected with the Tata works. The population, it is anticipated, will reach 100,000 to 150,000 when the extensions are complete, and a new large hospital and all its essential details will be installed, at a cost of £40,000. A rest house was provided in 1915 for the women working at the coke ovens, in which they might rest and sleep, and a crèche for their children, who are cared for by an Indian nurse.

There are three schools: firstly, the Mrs. Perin Memorial School, corresponding to an English primary and middle school, the average attendance being 162. It is partly maintained by the Tata Iron and Steel Company and partly by the Government grant. Secondly, the Night School, attended by about seventy chokras, or boy messengers, employed in the works. It is free, and two hours' nightly tuition is given in English and mathematics. Thirdly, the Mechanics' School, for the mistri class or mechanics. Elementary mechanics and drawing are taught. This school is partly financed by the company and partly by Government grants.

There is contemplated in addition to these a Girls' School, also a school open to all paying higher fees in which the curriculum sanctioned for European children by the Department of Public Instruction will be adopted. The directors are closely watching the schools, and, if they show success, are prepared to instal a general scheme of education in the three "R's" not slavishly modelled on the departmental curriculum

The juxtaposition of different white races to each other, and to the varied coloured colonies all in the trying tropical climate, no doubt tested the statesmanship of the men at the head of the Sakchi settlement. An adjustment is being gradually worked out—partly by elimination, as of the Germans, partly by the supersession of all foreigners by the people of the land, and partly by understanding promoted by time and habit.

It is projected that a model laundry, bakery and kitchen will be established, and women encouraged to attend and learn economical and hygienic methods. A model dairy and farm are contemplated, where experiments in the use of fertilisers and scientific agriculture may be carried out. Allotments are to be provided for all who care to cultivate them, and means are to be adopted for the encouragement of handicrafts. It is suggested that an annual exhibition might be held, say, on Christmas Day, where prizes would be awarded for the best production in each category. Education will form an important feature of this work, and in its elementary stages may take the form of instruction by pictures and model making—a combination of Kindergarten and Sloyd. Due attention to health and medical inspection of all new employees and subsequent supervision by welfare workers; fatigue study; swimming baths, provision for playgrounds and recreation; care of women before and after childbirth; study and preventive measures for skin diseases; isolation camp: investigations as to lighting and eye strain. In a book entitled "Medical Ethnology," now for sale in England, are discussed conditions suitable for life in the tropics and temperate zones for different races who have migrated into these zones, and it shows the different effects of tropical light on individuals, acting on their nerves, and through nerves on the whole organism, necessitating different conditions of food, clothing, protection of skin, and so on. Attempts will be made to associate workers themselves on committees, and to treat welfare as men's right, and not favour or policy of employer. It follows that there will be as little of obligatory welfare as possible. There is evidence that problems of the relation of the sexes have been present and have been considered, but there are no records of the method of treatment or of the success achieved.

All these matters are before the directors, and the whole comprehensive scheme which I have outlined has been submitted to them by expert advisers, and will be slowly adopted as opportunity occurs and funds are available.

It may appear that all this is only projected, and assumes the character of an advertisement, if I did not say that it is only after careful thought that I have dwelt at such length on these proposals, feeling that comprehensive welfare work must be included in all industrial enterprise after the war. The directors are alive to this, and desire that India may be at least co-equal with Western development, and as the scope of my paper embraces the effect of the Tata works upon industrial India, so important a factor should not be omitted.

It is highly important that due attention be given to sanitation, and at present sewage is treated in septic tanks. Careful investigation is being made into the comparatively new activated sludge system, and this will be shortly tried at Sakchi. The method consists in aerating the sewage by diffusion of air, which stimulates the bacterial action during its passage through several hundred feet of conducting channels, in

which the diffusers are placed, and subsequently its retention in a settling tank in which the flocculent matter is deposited and a clear effluent flows away, the sludge being subsequently dried and sold for fertilising purposes.

It may now be fairly conceded that the establishment of an industry so comprehensive in character must have far-reaching effects upon the development of the country. The railways of a country are indicative of its progress and prosperity. Already many millions of tons are annually borne upon tracks laid with Tata rails, and considerable extensions are projected so soon as the war terminates. In the near future waggons will be built at Sakchi from Sakchi steel, and transport raw material from the various sources to the steelworks, and thence to the seaboard or other destination.

The coal first coked to supply blast furnace requirements will yield tar for fuel and road-making; pitch for coating pipes, making briquettes and caulking purposes; sulphate of ammonia for fertilisers; benzol for explosives and traction purposes; toluol for munitions or blasting agents; naphthalene for disinfectants; not to mention anilines and dyes. It is expected that 2,250,000 gallons of benzol will be produced annually, part of this being directed to the manufacture of dyes, while a large quantity will be available for motor traction, and retailed at prices comparable with that of petrol will popularise the use of motor-cars and lorries more rapidly than has hitherto been the case. It is also quite feasible that motor vehicles may be manufactured as one of the subsidiary industries at Sakchi. Bazaars will dispose of Sakchi enamel ironware, cutlery and other hardware, buildings framed with Tata sections and roofed with corrugated sheets. The technical institute and research laboratory, which will educate chemists and engineers primarily for service at the steel works or subsidiary companies, will, no doubt, furnish skilled scientists for other Indian undertakings. Indian scholars above the average in social position and intellect may be attracted by the educational advantages at Sakchi, and thus include in the scientific professions the superior type of Indian who has hitherto confined himself to the professions of law, medicine, or commerce.

The proximity of a research laboratory and technological institute, contributing data and operating staff on more favourable terms than are demanded by Europeans, will prove factors of great importance to the potential investor, and, on the other hand, the existence of many diverse manufactories grouped round Sakchi will afford opportunities of practical shop experience to the students.

The chairman of the Tata Iron and Steel Company, Sir Dorab Tata, in his speech at the annual meeting of the Company last October, remarked: "We also contemplate to erect at Sakchi a research laboratory for metallurgy and chemistry, and your directors are considering whether they should not approach the Industrial Commission and Government of India with a view to making this laboratory a central national research laboratory in that part of India."

It is reasonable to suppose that after the conclusion of the war many investors will be attracted by the achievements of the several Tata undertakings to avail themselves of the Tata cheap power and semi-products, and initiate other industries which our investigations record as offering a good return on investment.

Although we devoutly hope that in our lifetime we may not be again confronted with the imminence of war, the potential value of this great steelworks must not be lost sight of, for an equipment which in times of peace will supply forgings and castings for ships, locomotives, or other industrial purposes, could, if the need arose, produce guns, shells, explosives, and all the essentials of warfare, by the utilisation of the resources of the country, both material and personal. The value to the Empire of such an arsenal will, I think, be readily admitted, and, should passage through the Suez Canal be cut off, would prove of great value in securing defensive equipments in the East. The success of the Tata Iron and Steel Company with capital subscribed by Indian financiers independently of any foreign aid, and to a considerable extent drawn from profits made in the Bombay cotton industry, inspired confidence in the ranks of Indian investors, whose subscriptions to the Tata Hydro-Electric Power Supply Company were promptly forthcoming, and similarly the capital for a new hydro-electric works, the Andhra Valley Power Supply Company, which is now under construction.

The existence of well-paid regular employment for the aborigines of the Sakchi district means considerable saving to the Government in expenditure on famine relief measures, and the steel companies' contribution to the revenue of the country for the year ending June, 1916, amounted to £130,000, which does not include other receipts from the population of 25,000.

Thus a portion of the vast and hitherto unex-

ploited wealth of India is being made productive. The profits of industry are realised and reinvested in new industrial undertakings. The status of the worker is being improved, and the influence of these factors upon the social and economic prosperity of the country is already widely appreciated, and will, as years go by, prove a determining feature in the industrial progress of India.

As the small pebble stirs the peaceful lake,
The centre mov'd, a circle straight succeeds,
Another still, and still another spreads,
Friend, parent, neighbour first it will embrace,
His country next; and next all human race.

The paper was illustrated by a series of excellent kinema views and lantern-slides.

DISCUSSION.

THE CHAIRMAN (Lord Lamington) said the paper was exceedingly interesting, in fact, a monumental record of an achievement usually associated in this country with blackness and dirt, but in the present case almost transformed into a fairy tale or a romance under the Indian skies. It was very satisfactory to know that the Indian Empire not only produced all those things that the Orient was famous for, but also had a wealth of iron ore which would make the mouths of some men interested in the iron trade water to think of. To him the most interesting feature of the paper was the evidence it afforded of the remarkable co-operation that had existed in bringing the enterprise to such successful fruition. It was a matter of pride to think that in our Indian Empire, under our great system of organisation and administration, a Parsee gentleman should have the enterprise and confidence to develop so great a work. He (Lord Lamington) was glad to think that our American kinsmen had been participants in the building up of so great an industrial achievement.

MR. ARTHUR BALFOUR, of Sheffield, said the meeting was greatly indebted to the author of the paper for the very lucid way in which he had described the wonderful plant which had been erected in India. Those who had to do with steel works would well know the difficulties which had to be overcome, even when skilled labour and technical help were available, as in this country; but the difficulties in India, increased by the war, must have been enormous, and great perseverance and determination had been shown by those who brought the great Tata works into being. The Company was to be congratulated on having added such a magnificent steel plant to the productive capacity of the Empire. The question arose as to what was to become of the steel that was produced, having regard to the fact that large plants in this country were also being quadrupled. But he was convinced that, with a lasting peace and security on which people could base enterprise in the future, there would be no difficulty at all in absorbing the whole of the iron and steel that could be possibly produced by this or any other country. The great thing to be aimed at both in India and in the Colonies was a large extension of railways, and that alone would absorb enormous quantities of steel. Then the shipbuilding programme of this country, to place us in the position that we were in before the war, would also absorb a very large quantity of steel. The war had shown how absolutely essential it was that the Empire should be independent in the matter of supplies of steel, and everyone would be only too glad to find Australia, New Zealand, India, or any other part of the Empire, assisting in producing such quantities of material that in future we might not find ourselves in the position we were in before the war. He remembered well the day when the Tata Company asked the Sheffield University to spare Dr. M'William to go out to India. He was a very valuable experimentalist at the University, but it was immediately decided that if anything could be done to develop industry in India the University should let him go at once, and he thought Dr. M'William had been of great assistance to the enterprise.

MR. C. H. B. BURLTON said it was a matter of very great importance that the mineral resources of India should be exploited more than they had been. It seemed to him to be a reflection on the Government of India that such vast wealth hitherto had remained unexploited, and that it would not have been exploited at all if it had not been for private enterprise, to which everything had been left with the exception of the agricultural resources of India, which had been fully developed by the huge irrigation works that had been constructed. With regard to the case of Joseph Heath, it was a very pathetic one, and it appeared that the East India Company let him down rather badly. He was a retired Indian civilian, and no doubt fully expected to benefit himself, but he would certainly have benefited the country at the same time if his enterprise had proved successful. As it was, he failed, but he deserved a better fate than having been allowed to die penniless. His enterprise was afterwards worked by the East India Company, and also the Government of India, for about twenty-one years. There was also another iron works which was a private enterprise; it failed, and the Government of India formed it into the Bengal Iron and Steel Company. That might also have come to grief if it had not paved the way for the third enterprise —that of Messrs. Tata, who were far too dogged and determined in every way to be overcome by any difficulties. They had prospered, and they deserved the success they had attained. The country must be very grateful to them for all the

benefits those large works had conferred, irrespective of any benefit Messrs. Tata might have derived themselves. The Company were dependent on the resources of India, but he noticed, from what the author said, that some million bricks were imported in about four years. He did not know why fire-bricks should be imported into India when the minerals were there for making them. He understood that Messrs. Tata were using their own magnesite deposits in Mysore for the making of the fire-bricks. Although the material no doubt was excellent, it was scarcely possible there could be enough minerals derived from Mysore to supply the vast quantity of bricks required, but there were other deposits, and if the Government of India would support private enterprise by giving a market for the sale of the goods those deposits could be developed. If people who owned deposits of magnesite or any other mineral, could turn it into the finished brick in the country, it would be a great advantage to the country, as well as to the individuals themselves, and stop the pernicious custom which at present prevailed of importing goods, which very likely had gone out of India to England and returned to India for utilisation. The exploitation of the deposits in India would result in furnishing sufficient material for the manufacture of fire-bricks and the lining of basic furnaces, and be very important in the present time of war, and of great advantage to our armies in Mesopotamia.

Mr. Alan A. Campbell Swinton, F.R.S. (Chairman of the Council), in proposing a vote of thanks to the author of the paper, said that anyone who had had to do with industries of any description could only admire the way in which the problem of the Tata works in India had been solved by Messrs. Tata: it was a most wonderful performance that such large works should have been established practically in the jungle. He was sure all who had heard the paper wished the Company every success, and hoped that their example would lead to the establishment of similar and other works in different parts of India.

Sir M. M. Bhownaggree, K.C.I.E., in seconding the motion, said the author had dealt with the subject in such a way that even those who had no technical knowledge had a good idea of what the Tata works were like. The paper fittingly paid a tribute to the memory of a great man, Mr. Jamsetji Tata. He did not think that Mr. Tata during his life obtained that recognition which was his due, either from the Government or from his own people. But to-day the seeds he had sown were giving a developing crop year by year, and people were beginning to realise what a great thing he had done for India. Personally he had a great reverence and admiration for those who conferred benefits on India, and he did not hesitate to say that Mr. Tata was perhaps the greatest benefactor of India and her people. He had introduced into the country an institution which would be far-reaching in its effects and of the greatest importance. If the admirable paper of Mr. Tuckwell, with its instructive illustrations, could be reproduced before Indian audiences in all parts of India—and even perhaps before audiences of certain Government officers who had the educational destiny of India in their hands—it would teach a great deal and point out the direction that should be followed in the education of the rising generation of India, in order that India herself might benefit, and that her connection with the British Government and British rule might be permeated with a sense of contentment, which he was perfectly sure the present situation of education did not inculcate.

The resolution was carried unanimously.

Mr. H. M. Surtees Tuckwell, in reply, said he was sorry that one misunderstanding had occurred. The time of which he spoke, when large quantities of bricks were brought in, was that when the works were first being built, when the work was actually being carried out in the jungle, and when the materials had not been carefully analysed and the resources were not properly understood. When war began, the Company was importing a certain number of bricks by permission of the Government, but recently they had had a cable from India to say that the Company were now entirely independent of English resources, and that the requirements of 40,000 bricks would all be made of Indian material in Indian factories, either through or in connection with the Tata steel works.

The Hon. Sir Charles A. Parsons, K.C.B., F.R.S. (Vice-President), in thanking Lord Lamington for taking Lord Sydenham's place, said that, as a former Governor of Bombay, it must have given him immense pleasure to see the great development which had occurred. Now that our Colonies and Dependencies had rallied round the Mother Country in her time of trouble, it was for the British people to give every support to any development in the Colonies and Dependencies like the one described in the paper, because such a development would not only be to the benefit of the Colonies and Dependencies, but add to the strength of the Empire.

The Chairman, in returning thanks, said the paper was one of the most remarkable he had heard read for a long time, and he thought the whole conduct of the enterprise reflected the greatest credit on those who had conducted it so successfully. With regard to rendering the Empire independent of outside resources, nobody could gainsay the necessity of that for one moment. He thought that in the past the Government of India had rather checked than encouraged private enterprise, but if they would forego their jealous

anticipations he was confident that the Indian people would come forward and invest their money to the profit of themselves and the great benefit of the country and of the whole of the Empire. Mr. Tuckwell had referred to what had been done in the way of encouraging co-operation and thrift amongst the workers, and perhaps it afforded a lesson that might be learned by some of our Government Departments at home in the present crisis. Mr. Tuckwell was to be congratulated not only on having read a very remarkable paper, but also on the fact that he himself was intimately connected with such a wonderful enterprise. It was an enterprise of a monumental character, and would no doubt form a turning-point in the transition of India from a great agricultural country to a manufacturing country.

The meeting then terminated.

SIR BRADFORD LESLIE, K.C.I.E., writes:—I was much interested by Mr. Tuckwell's admirable paper, having been an original director of the Barakar Ironworks. In 1916, in suggesting the construction of the Mesopotamia Railway to the Secretary of State for India, I said I had no doubt that rails could be obtained from the Tata Company, and I am glad to find that rails of their manufacture are now in use in that railway. I note that the Land Acquisition Act has been enforced by Government on behalf of the Tata Company; this the Government refused to do for the original Barakar Ironworks Company, because it was a private enterprise. Post-war sea freights will be greatly reduced; the Railway Board should require the companies to quote minimum rates to enable Tata products to compete with imported steel and iron at Karachi, Bombay, Rangoon, and the Straits. Tata should manufacture wheels and axles and waggons of standard type complete, including bogie stock for 60-feet rails, which are difficult to load and discharge at seaports. Saving fish-joints, long rails are economical, and in handling them Tata would have the advantage over shipping. What arrangements have been made to purchase and work up worn rails and other scrap steel? Formerly scrap rails were purchased at Rs. 25 per ton for export to the United States. Towards the end of the year 1870 I introduced the use of scrap rails for structural purposes in station buildings, and even as material for railway bridges. I also used them in constructing warehouses and factories for private firms, and in 1880 for constructing the East Indian Railway offices in Dalhousie Square. This created a market for scrap rails, and prices rapidly rose to Rs. 60 per ton, but heavy rail sections are not economical for building construction; it would be preferable to re-roll 80 lb. scrap to 56 lb. metre gauge rails, thus helping to fill up the deficiency caused by the war, or to cut them up and re-roll them as bar iron of more economical sections—this is a direction in which the Tata Company might do useful and profitable work. Most important of all is afforestation, to temper solar heat and improve rainfall; 118 degrees in the shade is a high temperature, and if the country were well wooded I am confident such a temperature would be very rare. When the East Indian Railway locomotive workshops at Jamalpur were first planned, the hills at the back were beautifully wooded; unfortunately the timber was not protected, the trees were felled, cut, and hacked for building and firewood, and soon nothing remained but bare rocks, which are reverberatory furnaces, absorbing sun heat by day and radiating it by night; the soil was washed away and it was found impossible to get the trees to grow again. Undergrowth and jungle should be cleared; it is a source of malaria, and is often the cause of the spread of forest fires. The villagers should be encouraged to graze their cattle and goats, keeping down rank vegetation as much as possible; but wherever trees will grow, trees should be planted, tended, and protected while young from goats and cattle, and all growing trees should be preserved. During sunshine every tree, through its leaves, is absorbing solar heat from the atmosphere and converting it into fixed carbon, charcoal; bind a wire round the trunk of a tree, in a year it will be found tightly strained and cutting into the bark. Not only the trunk and branches but the roots are by sun heat rendered latent and reproducible by burning. Thus forests temper atmospheric heat and cause precipitation from saturated air which would otherwise pass over bare ground from which heat is always radiating day and night. The value of forests is generally estimated in terms of timber produced. I am confident that their absorption of solar heat that would otherwise be radiated, though indirect, is in India really of far greater value than the timber produced. Of course, the Forest Department should understand and attend to all this, but my experience of Government Departments is not altogether satisfactory; and if the Tata Company realise the soundness of my observations I recommend them to take up afforestation, especially on the side of their location next the prevailing winds, and give it their earnest and intelligent attention.

MR. TUCKWELL writes, with reference to the above letter:—Sir Bradford Leslie's suggestion that the Tata Iron and Steel Works should manufacture wheels, axles and standard waggons complete has long had consideration from the directors; and the extensions, as I mentioned in my paper, will include a waggon factory, and probably embrace the manufacture of wheels and axles as soon as circumstances make it desirable. The purchase of scrap in large quantities is contemplated, to economise the use of pig-iron in the furnaces, and I imagine that the price of seconds for several years will be high enough to warrant worn rails being re-rolled. For several years our consulting engineer has utilised scrap rails for structural purposes, and we have shipped out from England

special rolls for re-rolling 90 lb. waste rails down to 30 lb. Sir Bradford Leslie's suggestions in regard to afforestation are most interesting, and will be forwarded to India for the attention of our Directors and consulting engineer.

CORRESPONDENCE.

WATER POWER IN GREAT BRITAIN (WITH SPECIAL REFERENCE TO SCOTLAND).

Mr. Newlands has rendered an invaluable service to the country by drawing attention to the vast resources of water power available in the United Kingdom and Ireland. The data given in his paper, which he must have taken endless trouble to collect, fully corroborate what I had stated in an article on "Scottish Water Power Development and its Possibilities," which appeared in the *Engineering Review* of September 15th, 1911.

That it is necessary, now more than ever, to enlighten the public on the importance and the real value of the water power available in this country, and to overcome the prejudice against its utilisation, prevalent even among engineers, is proved by the fact that I was told in the discussion of my paper on water power, read before the Institution of Electrical Engineers in 1895, that there was no water power in this country worth considering, especially on account of the irregularity of the water-supply. I have been able to show, and prove by numerous turbine installations with low and varying falls and a varying water-supply, for which I am responsible, that a constant and good water power can be obtained under such conditions. I was told that a water power which is varying, would have to be supplemented during part of the year by artificial power, generated by steam, oil or gas, at an increased capital outlay which would render such a mixed plant unremunerative. It seems to be entirely forgotten that the initial outlay for such auxiliary power forms a relatively small part of the total capital outlay, while the low annual expenses of the hydraulic plant are only slightly increased by the temporary use of auxiliary power required to keep up the supply to the demand of power. An absolutely constant power can hardly be found anywhere, and wherever it has been utilised to its full capacity it has been found necessary to add steam plant to comply with the increasing demand, and always to the advantage of the undertaking. I am informed that even at the Niagara Power Plant steam power is being added.

In order to ascertain the value of a water-supply as a source of power, and the extent to which it may be used for that purpose, it is not sufficient to go only by the records of the annual rainfall and the catchment area, which have often been misleading, but regular gaugings should be taken of any river likely to be utilised. The Swiss Government has for years, through its hydrographic department, taken such gaugings and is, therefore, in a position to state with accuracy the amount of power which we can obtain from our watercourses.

According to statistics published in 1912, the power obtainable in Switzerland is—

834,000 h.p.	for 12	months.
1,403,000	,, 9	,,
2,557,000	,, 6	,,

It may be of interest to know to what extent this power has been utilised—

Minimum	power on January 1st, 1914,	303,118 h.p.
Average	,, ,, ,, ,,	517,341 ,,
Maximum	,, ,, ,, ,,	775,550 ,,

In the development of water power the cost is, of course, the first point to be considered. It is generally held that high-fall plants are cheaper than medium or low-fall plants. This is correct only as far as the cost of the turbines is concerned, but long pipe-lines often make the cost of high-fall plants even more expensive than medium-fall plants of the same capacity.

With regard to the economical point of view, the noteworthy fact may be mentioned that in Westphalia, the centre of the German coal industry, whole valleys have been closed by large dams forming artificial lakes for the threefold purpose of regulating the flow of water for navigation of rivers, to prevent flooding, and to obtain power.

ALPH. STEIGER, M.Inst.C.E.

With reference to the important paper by Mr. Newlands, published in the *Journal* of January 25th, I should like to call attention to the extent to which our knowledge of the available water power depends on observations of rainfall. There are, I believe, no records of continuous stream-gauging in this country which have been continued long enough to furnish directly the average flow of any river. There are, however, many hundreds of long rain records which suffice for determining the average rainfall of which stream-flow is an ascertainable function. When, in 1897, the Royal Society of Arts presented the Albert Medal to Mr. G. J. Symons, in recognition of his work on founding and carrying on the British Rainfall Organisation, there were just over 3,000 records being kept by voluntary observers, and published annually at their own expense in *British Rainfall;* there are now more than 5,000 such records, enabling a fuller account to be given of the rainfall of the British Isles than of any other country in the world. Unfortunately observations are most scanty in just those remote and mountainous districts, which are of most importance for water power. Had the series of observations at Highland railway stations which Mr. Symons induced the Company to start in 1873, only been continued, we should now be in possession of numerous long records, the want of which can never be fully made good. I earnestly hope that all who have the welfare of the Highlands at heart will be moved by Mr. Newlands' paper to set about the immediate establishment of new rain-

fall stations. The observations are easy, the instruments cheap, even in war time, and I feel strongly that the advantages of voluntary co-operation outweigh those of formal Government control. All information as to rain gauges and the methods of observing will be supplied gratuitously on application to me.

HUGH ROBERT MILL,
Chairman of Trustees and Director
British Rainfall Organisation.

OBITUARY.

SIR JOHN WOLFE WOLFE-BARRY, K.C.B., LL.D., F.R.S.—By the death of Sir John Wolfe-Barry the Society loses one of its most distinguished Fellows, and the Council one of its ablest and most efficient members. His death occurred on January 22nd, at his residence, Delahay House, Chelsea Embankment, at the great age of eighty-one, as he was born in December, 1836, in London. He was the fifth and youngest son of the eminent architect, Sir Charles Barry, R.A., who also was a member of the Society, which he joined in 1836. The family was a remarkable one, for of Sir Charles's five sons, four achieved distinction in their several professions. The third son, Edward, "completed his father's work, and succeeded to his reputation." He, like his father, was a Royal Academician. The eldest, Charles, also followed his father's profession, and acquired a considerable practice, and became President of the Royal Institute of British Architects. Alfred, the second, became Bishop of Sydney and Primate of Australia.

John Wolfe Barry (he combined his Christian name of Wolfe with his surname, and became Wolfe-Barry in 1898) was educated at Trinity College, Glenalmond, where his brother Alfred was Sub-Warden, and at King's College, London. He was articled to Sir John Hawkshaw, under whom he served as assistant resident engineer in the construction of Cannon Street and Charing Cross railway stations, with the two great bridges leading to them. In 1867 he set up on his own account, and soon laid the foundations of a large and extensive practice, which developed on lines certainly influenced by the important works on which he was employed in his youth. Throughout his long and successful career it was in dealing with transportation questions that his great reputation was acquired, and it was the construction and development of railways, roads, canals, harbours and docks that occupied practically the whole of his attention as a professional engineer. The two great works with which his name is most closely associated in the public mind are probably the London Tower Bridge and the South Wales Barry Docks, but these are only two on the long list of important works carried out by Sir John Wolfe-Barry, or under his advice, in the United Kingdom as well as in India, Africa and China. This brief allusion to his professional life-work must suffice for these columns, but it may be permitted to refer those who desire fuller information to the record which appeared in *Engineering* of last week, where his professional career is treated in full detail.

Mr. Barry, as he was then, joined the Society in 1890. In 1894 he was elected on the Council, and on it he served continuously till his death, with only one short break in 1910. In 1898 he became Chairman of the Council, and the previous year he had received the K.C.B., the C.B. having been given him three years before, after the completion of the Tower Bridge. He availed himself of the opportunity afforded by the two addresses he delivered as Chairman of the Council to bring prominently before the public his views on London transportation. The first of them was on "The Streets and Traffic of London," and the second on "London Communications." In them he worked out a full and comprehensive scheme for improving communication along the main arteries of traffic by facilitating the passage of the two great currents —east and west, south and north—at the points where they crossed. At such points it was proposed that the streams should be led to different levels one over the other, suitable access from one to the other being provided by slightly inclined roadways. The scheme was perfectly simple and practicable, though obviously costly in execution, but it never got beyond the stage of suggestion. After the expiration of his term of office Sir John's interest in the work of the Council in no way declined, for he was a regular attendant up to last autumn.

As Chairman of the Council he became an *ex officio* member of the Governing Body of the City and Guilds Institute, and this led to his devoting much attention to the subject of technical education. Eventually he became Chairman of the Executive Committee of the Institute, and took a leading part in its work, for after he ceased to represent the Society he was continued on the Governing Body of the Institute as one of the representatives of the Goldsmiths' Company. He was for some time on the Court of this company, and in 1912 he served as its Prime Warden. In this capacity, as well as in his chairmanship of the Institute's Committee he was a successor of Sir Frederick Bramwell, one of the founders of the Institute and its first chairman.

His services to education in connection with his own profession, however, go back to an earlier date, for it was largely owing to his influence, and to the stress laid upon the need for raising the standard of qualification for membership of the Institution in his two Presidential addresses (1896 and 1897) to the Institution of Civil Engineers, that its regulations were remodelled and an examination instituted for admission to the initial stage of its membership.

The piece of work on which (apart from his purely constructive engineering works) he probably most prided himself, and the one which must always be associated with his name, was

the establishment of the Engineering Standards Committee. Put briefly, it may be said that the object of this committee is the standardisation of all materials employed in engineering. In 1901 a committee was appointed, at his initiative, by the Council of the Institution of Civil Engineers, to consider the advisability of standardising various kinds of iron and steel sections. The work of the committee was so successful that it soon developed into an important organisation of great influence, which has had a most beneficial effect on the industry, resulting in large economies. The successful work of the committee and its influence on the prosperity of the country formed the subject of the "James Forrest Lecture" delivered by Sir John in May, 1917, and this indeed was probably his last appearance before a public audience.

It will be seen that his professional career extended just over fifty years—from 1867 to 1917—and he continued it with unabated vigour until his last illness, for if during the last few years he had somewhat retired from actual professional work, he certainly did not relax in his many public engagements. His personal vigour and vitality seemed unimpaired, as was for instance shown by the excellent Forrest lecture which, as above stated, he delivered last year. A man of considerable business capacity and shrewd common-sense, he possessed also a singularly genial nature and a very pleasant manner. These qualities gained him a host of friends, as was shown by the crowd which filled St. Margaret's Church, Westminster, at the funeral service last Saturday. If he had outlived nearly all his contemporaries, he had gained the esteem and the regard of a generation of younger men both in and outside the great profession of which, at the time of his death, he was the admitted and respected head.

Thomas Abercrombie Wilton.—The death of Mr. Thomas A. Wilton took place on January 16th. He was elected a member of the Royal Society of Arts in 1870, and contributed several letters to the *Journal* on subjects connected with Indian and African trade. An eminent accountant, he was one of the oldest members of the Royal Statistical Society, which he joined in 1855. He contributed a number of papers to their Proceedings, and served on their council for many years. For the last twenty-five years he acted as Vice-Chairman of the Inspection Committee of Trustee Savings Banks.

John Scudamore Sellon.—Mr. John Scudamore Sellon died in London on January 16th, at the age of eighty-one. Early in life he entered the firm of Messrs. Johnson, Matthey & Co., assayers and refiners to the Bank of England and Royal Mint, and he took a prominent part in the research work and industrial developments connected with platinum and other rare metals with which the name of his firm is associated. He was also deeply interested in electrical engineering, having been connected with Faure, Brush, Swan, Lane-Fox, and others in their early work in lighting and storage.

Mr. Sellon was elected a member of the Royal Society of Arts in 1882, and on several occasions he took part in discussions on subjects relating to electric lighting.

NOTES ON BOOKS.

The Preservation of Wood. By A. J. Wallis-Tayler, A.M.I.C.E. London: William Rider & Son, Ltd., 1917. 10s. 6d. net.

The subject-matter of this book is opportune to the moment. Timber is at a premium. By not less than 100 per cent. have the prices of imported woods advanced—now steadily, now *per saltum*—since 1914. The demand for home-grown and home-growing timber, mature and immature, has left a mark upon our own plantations that will not readily be effaced. The woods and forests of the world are in course of a lamentable denudation. If, then, in the old days of plenty, the application of some preservative process to wood which was intended for constructional use was recognised as an economic desirability, how much the more is it now, and must it be in the future, a clamant necessity?

In these circumstances, Mr. Wallis-Tayler has done well to draw up this monograph on the history, methods and economics of timber preservation.

In an introductory chapter the author submits a rapid sketch of the evolution of its practice, from the early days of Egypt and Rome, and the use of bitumen and the oils of olive, cedar and spikenard, down to the end of the eighteenth century, and the introduction, at the instigation of Congreve, of the all-important creosote processes. From that period he follows, with considerable detail, the numerous investigators who, throughout the nineteenth century, pursued many and diverse paths of experiment and practice in England, on the European continent and in America.

Upon this follows a short study of the natural history of the enemies of timber: fungoid, and low in type, as in the "wet" and "dry" rots; animal, and higher in the scale of organisation, as in teredo and the ants. Here the gain arising from the use of appropriate preservative processes is well brought out, not only in the text, but by a series of illustrations showing the ravages to which untreated wood is subject.

Thence we pass to the consideration of the methods, natural and artificial, employed in the seasoning of timber; a stage through which, save in the paramount emergency of war, all woods must pass before preservative treatment can be applied with profit. A number of the most recent and approved forms of drying plant, such as are now in use in this country and abroad, are clearly described and figured; and the physical factors concerned in their employment are dealt with through the medium of a graph and a succession of numerical tables.

And thus we reach the heart-wood of the matter: the theory and practice of the application of chemical substances to seasoned timber with a view to increasing the duration of its soundness when in constructive use.

It is not possible, within the limits of a short review, to follow the author through the ramifications of this subject. Sufficient it must be to say that, after an admirable exposition of the theories and hypotheses underlying the different methods that are in practical employment, and dividing the latter under the two main heads of "open tank" and "pressure" systems, he describes the creosoting processes of Bethell, Rueping, Lowry and Curtis-Isaacs; the zinc-creosote processes of Rutger and Card; the creo-resinate process of the United States Wood Preserving Company; the saponified creosote process of Collins; the early bichloride of mercury process of Kyan; the zinc-chloride process of Burnett; the sulphate of copper processes of Boucherie and Hasselman; the saccharine process of Powell; and many others.

A succeeding chapter deals with some fifteen proprietary preparations which are available for use either within the body of the timber or as an external coating. The next treats of the absorption limit, and of the increased durability of preserved wood. Another concerns itself at some length with the application of fire-proofing and fire-retardant processes. And the last is devoted to the all-important subject of the cost of the various preservative treatments. The book comes to an end with some thirty-seven pages of formulæ, tables and memoranda, to which—one ventures to suggest—a Schedule of Processes based on the ratio

$$\frac{\text{Increased durability of timber}}{\text{Cost of preservative treatment}}$$

would be a useful addition.

A work prepared in these days of stress and hurry can hardly fail to show a few blemishes. One is inclined to quibble with the statement that ". . . the gases evolved . . . produce fungi . . ."; and a lengthy footnote on page 19 is, through some accident, unintelligible as it stands. Such small faults will, doubtless, be amended in the next edition.

Mr. Wallis-Tayler is to be congratulated on the production of an eminently useful book. G. E.

The Industrial and Artistic Technology of Paint and Varnish. By Alvah Horton Sabin, M.S. Second Edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. 16*s.* 6*d.* net.

The use of varnish dates back to very early days, the oldest in existence being probably that used on wooden mummy cases made in Egypt some twenty-five centuries ago. This appears to be a solution of resin in an essential oil, and it is so durable that it has stood exposure to the air all this time, and still looks well. Mr. Sabin has also discovered that the value of white lead has been properly appreciated for almost as long, for he refers to a passage in Xenophon's *Economicus*, where one of the speakers mentions that his wife was at one time in the habit of rubbing it into her skin to make her face look white, and then dyeing her cheeks and lips with alkanet to make them red.

From this it will be seen that the author has not neglected the early history of his subject, which is summed up in a short but interesting introductory chapter; but his aim is "to give a correct general outline of the subject of paints and varnishes, with a brief account of their modern use and of the principles which are involved in their fabrication and application." The book is divided into twenty-four chapters, of which three are devoted to linseed oil. This second edition is nearly a third larger than the original, and among the most important additions is the section on the use of tung-oil in varnish-making. This, says the author, has entirely changed the character of cheap and medium-priced products. Varnishes containing it dry with a rapidity and hardness unknown before; and they also possess remarkable water-resisting properties.

The volume is written in a careful and scholarly style, and the opinions are based on the long personal experience of the writer.

A Handbook of Elocution. By Edward Minshall. London: John Murray. 1*s.* 6*d.* net.

It ought hardly to be necessary to insist upon the advisability of teaching children to speak their words clearly, but one notices among many of the young people of to-day a tendency to a slip-shod enunciation which cannot but be disadvantageous to them if they have to play parts of any importance in later life. This little handbook has been compiled for the benefit of those who are victims of bad elocutional habits formed in their youth, and who desire to correct their faults. It is the work of one who has had long experience in teaching elocution at the City of London College, and it will be found full of sound advice likely to be helpful to those for whom it is intended.

GENERAL NOTES.

British Coal in 1916.—The total value of the minerals raised in the United Kingdom in 1916 amounted to £214,034,524—an increase of £43,576,266 as compared with 1915. The total output of coal was 256,375,366 tons, and the value £200,014,626—an increase in the output of 3,169,285 tons, and in the value of £42,183,956, on the figures for the preceding year. The quantity of coal exported, exclusive of coke and manufactured fuel and of coal for the use of steamers engaged in foreign trade, was 38,351,553 tons, of which France received over 17½ million tons, Italy nearly 5¾ million tons, Norway over 2¼ million tons, Denmark over 2¼ million tons, Spain over 2 million tons, Sweden over 1½ million tons, and the Netherlands over 1¼ million tons.

GROUNDNUTS IN THE UNITED STATES.—The value of the groundnut crop in the United States, according to *Agriculture*, has risen from twelve million dollars in 1908 to fifty-six million dollars in 1916. By slight adjustments of machinery cotton-seed mills can be used for crushing the nuts; but an increasing proportion of the crop is being used for food purposes in the uncrushed state. Experiments under the auspices of the Chemical Bureau of the Department of Agriculture are said to hold out promise of the production from groundnut meal of a bread equal in nutritive value and palatability to wheaten bread.

SCANDINAVIAN AIR TRAFFIC.—At a recent meeting of the Aeronautical Society in Stockholm, Captain Dahlbeck gave a survey of aeroplane traffic in Sweden. Denmark has no air traffic society as yet, but a large new factory for aeroplanes is in full swing. Denmark is taking an interest in comprehensive international schemes—such as England-Denmark-Sweden and Germany-Sweden-Norway routes. In Denmark the legal side of the question—the protection of national territory and the granting of concessions—is attracting a good deal of attention at present.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

FEBRUARY 6.—WM. FRECHEVILLE, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines, "The Development of Mineral Resources of the Empire." SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

FEBRUARY 13.—LORD LEVERHULME, "The Relations between Capital and Labour — Reasonable Hours, Co-partnership, and Efficiency."

FEBRUARY 20.—MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." SIR ASTON WEBB, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

FEBRUARY 27.—SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

MARCH 6.—A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

MARCH 13.—PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] The ARCHBISHOP OF CANTERBURY will preside.

MARCH 20.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

Dates to be hereafter announced :—

MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War."

MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

PERCY SHUTTLEWOOD, Ministry of Food, "The Food Situation in Germany."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m. :—

FEBRUARY 14.—SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Hide Trade and Tanning Industry of India." The RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

MARCH 14.—

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India."

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m. :—

FEBRUARY 5.—C. DU PLESSIS CHIAPPINI, Trades Commissioner for the Union of South Africa, "The Industrial Resources of South Africa."

The RIGHT HON. VISCOUNT GLADSTONE, G.C.B., G.C.M.G., G.B.E., will preside.

MARCH 5.—

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced):—

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, "High Temperature Processes and Products." Three Lectures.

Syllabus.

LECTURE III.—FEBRUARY 4.—*Products and their Uses.* Artificial graphite for various purposes—Carborundum for abrasion and refractory purposes—Alundum and silica for chemical apparatus and refractories—Calcium carbide for making acetylene—Pure metals by thermit processes—Siloxicon and other silicon—Carbon compounds for refractories and thermal insulators—Aloxite and its uses.

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." Three Lectures.

February 18, 25, March 4.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEBRUARY 4...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. C. R. Darling, "High Temperature Processes and Products." (Lecture III.)

Chemical Industry, Society of (London Section), at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.30 p.m. Meeting of London Chemists to consider the formation of a British Association of Chemists.

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Mr. W. A. Simmons, "Food Control as affecting Agriculture."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

TUESDAY, FEBRUARY 5...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Mr. C. du Plessis Chiappini, "The Industrial Resources of South Africa."

Röntgen Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "The Problems of British Anthropology." (Lecture I.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. The Hon. Sir Francis J. E. Spring and Mr. H. H. G. Mitchell, "The West Quay of Madras Harbour."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Mr. D. S. Smith, "Exhibition of slides of Reptiles taken in the Gardens." 2. Mr. T. E. Whitehead, "Notes on the Dingo in Australia." 3. Professor B. L. Bhatia and Baini Prashad, "Notes on the Skull of *Rana tigrina*." 4. Mr. G. A. Boulenger, "Description of a new Snake of the genus *Oligodon*, from Upper Burma." 5. Dr. R. Broom, "On a new and a rare Species of the Golden Mole (*Bematiscus*)."

WEDNESDAY, FEBRUARY 6...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Professor W. Frecheville, "The Development of the Mineral Resources of the British Empire."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Geological Society, Burlington House, W., 8 p.m.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 5 p.m. 1. Annual General Meeting. 2. Mr. A. E. Parkes, "A modified Acetic Acid Reagent for Valenta Tests." 3. Messrs. E. R. Bolton and C. Revis, "Oiticica Oil—a new drying oil."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Mr. J. G. Turner, "What Steps are possible to Improve the Teeth of the Nation?"

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Dr. R. Munro, "Scottish Crannogs: their Structure, Distribution and Chronological Range."

THURSDAY, FEBRUARY 7...Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. The General Secretary, Two Bibliographical rarities of the Society's Library: (*a*) "Cupani, F., Panphyton siculum, 1713"; (*b*) "Du Gort, J. & P., L'Histoire et Pourtrait des plantes. Lyon, 1561." 2. Mr. H. P. Guppy, "Plant Distribution from the Standpoint of an Idealist."

Chemical Society, Burlington House, W., 8.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Napier Shaw, "Illusions of the Atmosphere: the Travelling Vortex and the Cyclonic Depression." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. F. M. Duncan, "Curiosities of Crustacean Life."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. (Kelvin Lecture.) Professor M. Maclean, "Kelvin as a Teacher."

FRIDAY, FEBRUARY 8...Royal Institution, Albemarle-street, W., 5.30 p.m. Principal E. H. Griffiths, "Science and Ethics."

University of London, Slade School of Fine Art, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture IV.)

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. Annual General Meeting.

SATURDAY, FEBRUARY 9... Royal Institution, Albemarle-street, W., 3 p.m. Mr. M. P. H. Loyson, "The Ethics of the War." (Lecture II.)

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Royal Society of Arts

CANTOR LECTURES.

A full list of the Cantor Lectures which have been reprinted from the **Journal** and published separately may be obtained on application to

THE SECRETARY, John Street, Adelphi, London, W.C.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, or the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

HOWARD AND OTHER LECTURES.

Heavy Oil Engines. Four Lectures. By Captain H. RIALL SANKEY, R.E., M.Inst.C.E. (1912.) Price 1*s*.

Aeronautics. Three Lectures. By Prof. J. E. PETAVEL, D.Sc., F.R.S. (1913.) Price 1*s*.

Surface Combustion. Three Lectures. By Prof. WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S. (1914.) Price 1*s*.

Motor Fuel. Three Lectures. By Prof. VIVIAN B. LEWES, F.I.C., F.C.S. (1915.) Price 1*s*.

Coal and its Economic Utilisation. Three Lectures. By Prof. JOHN S. S. BRAME. (1917.) Price 1*s*.

The Shortage of the Supply of Non-Phosphoric Iron Ore. Two Lectures. By Prof. WILLIAM GEORGE FEARNSIDES, M.A., F.G.S., M.Inst.M.E. (1917.) Price 1*s*.

Journal of the Royal Society of Arts.

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FRIDAY, FEBRUARY 8, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, FEBRUARY 13th, at 4.30 p.m. (Ordinary Meeting.) LORD LEVERHULME, "The Relations between Capital and Labour—Reasonable Hours, Co-partnership, and Efficiency."

THURSDAY, FEBRUARY 14th, at 4.30 p.m. (Indian Section.) SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Indian Hide and Leather Trade." The RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On Monday afternoon, February 4th, MR. CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Lecturer in Physics, City and Guilds Technical College, Finsbury, delivered the third and final lecture of his course on "High Temperature Processes and Products."

On the motion of the Chairman, SIR HENRY TRUEMAN WOOD, a vote of thanks was accorded to Mr. Darling for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

COLONIAL SECTION.

Tuesday afternoon, February 5th; The RIGHT HON. VISCOUNT GLADSTONE, G.C.B., G.C.M.G., G.B.E., in the chair. A paper on "The Industrial Resources of the Union of South Africa" was read by MR. C. DU PLESSIS CHIAPPINI, Trades Commissioner for the Union of South Africa.

The paper and discussion will be published in the *Journal* of February 15th.

NINTH ORDINARY MEETING.

Wednesday afternoon, February 6th; SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., in the chair. A paper on "The Development of the Mining Resources of the Empire" was read by MR. WM. FRECHEVILLE, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines.

The paper and discussion will be published in the *Journal* of February 22nd.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers will be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 30th, 1918; SIR ARTHUR D. STEEL-MAITLAND, Bt., M.P., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Barron, William Alfred, M.Inst.M.M., London.
Bedwell, George Champion, Cambridge.
Brander, James, Bristol.
Britton, William, M.I.Mar.E., Aden.
Challen, Charles Hollis, London.
Elliott, Sir Bignell George, K.B.E., London.
Guild, John, Honolulu, Hawaii.
Hearn, John Edward, Luton.
Hind, John, Kohala, Hawaii.
Lewis, A., Honolulu, Hawaii.
Lidgate, Anthony, Hamakua, Hawaii.
Lucas, Harry, Birmingham.
Quittenton, Charles Henry, Warlingham, Surrey.
Searle, Richard Charles, Leicester.
Sen, Nirmul Chunder, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Armstrong, Lieut.-Colonel J. A., R.E., London.
Ashford, John, M.I.Mech.E., India.
Brecknell, Henry Edwin Frank, Bristol.
Brown, Lieut.-Colonel F. Leslie, D.S.O., South Africa.
Bunker, George R., Yonkers, New York, U.S.A.
Butcher, Arthur Douglas Deane, Egypt.
Butler, William, Pittsburg, Pennsylvania, U.S.A.
Carnt, Engineer-Commander Albert John, R.N., Peterborough.
Carruthers, Engineer-Captain David John, R.N., Sevenoaks.
Dommett, Lieutenant William Erskine, R.N.V.R., Bedford.
Geejgarh, The Chief of (Thakur Sahib Kushal Singh), India.
Gill, Harry, Kinlochleven, Scotland.
Graham, Alfred H. Irvine, Assoc.M.Inst.C.E., Surbiton.
Heckford, Arthur Egerton, Birmingham.
Hood, James Maclay, Glasgow.
Hugon, G. R., Manchester.
Hunter, Sir John, K.B.E., London.
Hurren, Frederick Harold, Coventry.
Ingle, W. L., J.P., Leeds.
Kemp, Henry Thomas, London.
Kreglinger, Albert, London.
Leigh, E. B., Chicago, U.S.A.
Maxwell, Robert W., Frant, Sussex.
Morch, Jacob, London.
Owen, Alfred Ernest, Darlaston, Staffs.
Pearson, John Andrew, Toronto, Canada.
Pierce, Edward Lily, Syracuse, New York, U.S.A.
Pinckard, Mrs. R. A., London.
Richardson, Ralph, Weybridge, Surrey.
Saunders, Samuel Edgar, M.I.N.A., Isle of Wight.
Scott, Thomas Henderson, Assoc.M.Inst.C.E., Trinidad.
Simms, William Archer, Swansea.
Smith, Major S. Heckstall, London.
Tucker, Percy Earle, Yeovil.
Twiggs, Alderman H. W., Bristol.
Waddington, George, London.
Wakefield, Alderman Sir Charles Cheers, Bt., London.
Walker, Henry T., London.
Welch, Henry John, Bromley, Kent.
Wilkinson, Samuel Blaze, Northampton.

The paper read was—

THE MANUFACTURE OF MARGARINE IN THE UNITED KINGDOM.

By Sir William George Watson, Bt.,
Chairman of the Maypole Dairy Company.

When your Secretary invited me to give you a paper on the use and manufacture of margarine in Great Britain, he informed me that a very interesting paper upon the subject of Butterine or Oleo-Margarine butter, was read before your Society by the late Mr. Anton Jurgens in 1884.

On perusing that paper I am struck with its apologetic character. In those days it was apparently considered necessary to apologise for either manufacturing or selling margarine. To-day apologies of this character are unnecessary. Margarine has now won by its own merits an established position in most countries and has, since the war, proved a boon to all classes of the population. This in spite of the admitted fact that since the outbreak of war the quality of the "overkept" or "held up" raw materials has sometimes affected the quality of the product, and will probably reduce the quality still further in the near future.

I cannot agree that the success of margarine is caused through its similarity in appearance to butter, and in proof of this it is only necessary to mention that the greatest consumers of margarine per head of population are the Danes, who many years ago passed laws to forbid manufacturers making margarine which was coloured to resemble butter.

These laws were passed in Denmark to protect the very important Danish butter industry, and were probably at that time also expected partially to kill the growing margarine industry. Instead, they had the curious effect of greatly increasing the home consumption of margarine in Denmark, and of inducing the largest Danish margarine manufacturer, Mr. Otto Monsted, to build works in England in 1888 to enable him to retain his British customers who still wanted to buy coloured margarine.

The establishment of these works, in which my family became partners in 1889, was a principal cause of the increase in the British manufacture of margarine. To-day over 80 per cent. of the margarine made in Great Britain is under the control of men who were trained in the factories established by Mr. Otto Monsted and his partners or successors, The Maypole Margarine Works, Limited. This proves how

bringing new industries into this country disseminates technical knowledge.

Although the margarine industry was first established on a large scale in Holland, Denmark was a very close second in the field. The Dutch makers established factories in Germany and Belgium when those countries put a tariff upon margarine, but they did not take any steps to establish works in Great Britain until the difficulties caused by the present war practically compelled them to do so. After first establishing themselves in Holland and Germany, it paid them best under the conditions to import their raw materials (chiefly from British Colonies) to Germany and Holland and manufacture them there for the British markets.

It has always seemed to me to be unwise for Great Britain to continue dependent upon foreign countries for the manufacture of important foods, especially so for food made from raw materials produced in the British Empire. Maypole has always endeavoured to encourage and extend the British manufacture of margarine, and in recent years the crushing of edible nuts and the refining of the resultant edible fats.

After the outbreak of war, the then Colonial Secretary (Mr. Bonar Law) appointed a committee, upon which I had the pleasure of serving, under the chairmanship of our honoured Chairman of to-day (Sir Arthur Steel-Maitland). This committee was appointed to advise the Government on the steps to be taken to establish crushing and refining mills in the United Kingdom, and to extend the British margarine industry, and so provide a home market for the copra, palm kernels, and other oil nuts and seeds which the British colonies had previously sent to Germany.

This committee made their report, but I fear it did not then have the desired effect, as Maypole's factory could only work at half its capacity in 1916, owing to the handicap and restrictions on the sales at Maypole's branches, which were caused by the monopoly which was then given to sugar retailers and their power to make "conditional sales."

My protests and appeals to the Government to remove the handicap on our output were unsuccessful at that time, and I shall always consider the Government were very badly advised to ignore my protests, and continue to curtail and handicap the British production and sales of margarine during that war year, when the average imports of butter showed a decrease of 1,614 tons per week. It would have been much wiser to have then encouraged Maypole, and asked them further to increase their factory and output.

However, early in the year 1917 the British Government decided to give encouragement to the home manufacture of margarine. They then prohibited and made it an offence to make "conditional sales" with sugar. This prohibition (when enforced) removed the handicap on "Maypole" sales of margarine, and enabled the company to work their factory at its full capacity, and promptly to add over 900 tons to their weekly output and sales; this at a time when extra supplies of margarine were urgently wanted, owing to the increasing shortage of butter and the effects of the submarines and blockade policy on the Dutch supplies. In this year the British Government also prohibited the export of oil seeds to Holland, so the Dutch margarine makers had then to import their raw materials for making margarine in the form of oil. This prohibition considerably lessened the supply of cattle feeding-cakes for the Dutch cattle, and at the same time increased the supply of food for British cattle.

During the first six months of 1916 Holland had sent over 4,000 tons of meat, butter and cheese per week to Germany, and it therefore seemed advisable for our country to discontinue sending to Holland the raw materials for manufacturing cattle feeding-cakes.

The figures given on p. 214 show the large decrease in the imports of butter and the increase in the imports of margarine in 1916, and the large increase of the home manufacture of margarine in 1917, when the restrictions on Maypole sales and output were removed.

In 1913 and 1914 over two-thirds of the home production of margarine was made at Maypole's factories, and they now manufacture over 2,000 tons a week at their Southall factory. This quantity is about equal to the average weekly production of butter in the United Kingdom.

Since the outbreak of war, Maypole and their chemists have been instrumental in assisting two of the largest British companies—Messrs. Lever Brothers, Ltd., and the Wholesale Co-operative Society, Ltd.—to commence the manufacture of margarine in this country: and the two largest Dutch companies have nearly completed margarine works here, so there is every reason to hope that British factories will soon be in a position to render us independent of foreign countries for the whole of our supplies of margarine.

When Mr. Anton Jurgens read his paper in

	1913.	1914.	1915.	1916.	1917.
	Tons.	Tons.	Tons.	Tons.	Tons.
Average weekly quantity of margarine manufactured in Great Britain	1,611	1,728	2,219	2,479	3,564
Average weekly quantity of margarine imports from all countries	1,460	1,470	1,973	2,647	*
Average weekly quantity of margarine imports from Holland	1,427	1,445	1,947	2,633	*
Average weekly quantity of butter imports from all countries	3,980	3,831	3,706	2,092	*
Average weekly quantity of butter imports from Denmark	1,641	1,682	1,276	1,091	*
Average weekly quantity of butter imports from Holland	147	177	43	35	*

* Not published.

1884, margarine was manufactured almost exclusively from animal fats and liquid oils. To-day, coconut oil and palm-kernel oil have nearly displaced the animal fats.

In the discussion which followed the reading of Mr. Jurgens' paper, Mr. Otto Hehner said that coconut oil was the only vegetable fat which at all resembled butter. At that time the manufacture and preparation of vegetable fats for other purposes than soap-making were only in their very first stages.

However, gradually new methods of treating the vegetable fats were introduced, and in the early nineties coconut fats had already gained a certain place in the market as a cooking fat. During the following ten years, as refining methods were perfected, it slowly but surely found its way into the manufacture of margarine.

Other fats, such as palm-kernel oil, were also introduced, with the result that about 90 per cent. of the margarine manufactured is now made exclusively from vegetable fats and oils; and in my opinion the quality, when scientifically manufactured, is superior to that made with animal fats. Before the war the prices of vegetable fats were often equal to the prices of animal fats, but since the war the greater scarcity of animal fats has made the latter more expensive than the vegetable fats.

Many and various difficulties have had to be overcome before the vegetable fats could be refined to the degree of perfection required to enable them to be utilised in the manufacture of margarine.

Not only has it been necessary to design, improve, and again improve, upon the milling machinery used for the crushing of the nuts, but numerous processes, both physical and chemical, have had to be devised to free the crude oil from all colour matters, from the contents of free, fatty acids, and from odour—the last being due to the presence of small quantities of volatile substances.

Of these processes should be mentioned:—

1. The washing of the fats with hot water, so as to remove albuminous matters.
2. The filtration and bleaching with various hydro-silicates.
3. Neutralisation with caustic alkali.
4. Treatment in specially designed vessels, with superheated steam, to remove the volatile substances.

Every process has to be carried out with the most minute care and attention, and in continuous co-operation with the chemical laboratory, in order to ensure a finished product practically without taste, smell, or colour, as the margarine makers of to-day are most particular in the choice of edible fats.

Before leaving the subject of oil refining, I would mention the very great developments in this industry due to the war; for instance, Maypole's refining works at Erith have practically trebled their output.

I will now turn to the margarine-making proper, and continue with a description of the manufacture and processes as it progresses.

The solid vegetable fats are, as a rule, hard and brittle, and the first step is to melt and mix them with the amount of liquid oil necessary to soften them to such an extent that they can be easily spread on bread.

The mixture of fats and oils is practically

colourless, and as a yellow colour is desirable a small amount of butter colour is added.

The next step is the churning process, wherein the fats are churned with ripened skim milk in such a way that a very intimate emulsion of milk and fat is formed.

This churning process has undergone considerable developments, and I am pleased to say that our works have been among the pioneers in this direction. Five or ten years ago the process was carried out in large vessels of several tons capacity, provided with a steam-driven stirring device. The whole arrangement was very bulky and expensive, and necessitated constant attention and considerable loss of time.

The new plant consists of a motor-driven emulsifier, in which the emulsification is carried out continuously. This arrangement requires very little attention, and only a fraction of the power needed for the old plant. The new emulsifying plant has been in use in our works for several years, and has also been adopted in several other factories with which we work together in technical matters.

The liquid emulsion produced in the emulsifiers is spread on the surface of rotating cooling drums, and thereon cooled to such an extent that it immediately sets and is scraped off the drums as finely crystallised flakes.

The very fine and uniform crystallisation of the fats essential for the making of vegetable margarine has only become practical by the introduction of the above-mentioned cooling device, and by the guide of microphotographic reproduction of the crystallisation formed thereon.

In this direction also I am pleased to say that our works have been doing pioneer work, and the first successful drum-cooling was carried out in Southall as early as 1906. Before the introduction of the surface-cooling of margarine emulsion, the cooling was generally done by spraying the emulsion into icy-cold water.

At this stage of the manufacture the salt is added, and the margarine is worked on butter rollers and butter blenders until it has a consistency which resembles butter.

The milk and its treatment is of the greatest importance in the manufacture of margarine. It has been found necessary to procure the best and freshest milk obtainable, and to make such arrangements that it is received in our dairy within six to eight hours from milking time.

In the dairy the milk is separated (the cream being used for butter-making), and the skim milk is pasteurised and cooled practically to freezing-point and then run into tanks, where it is stored under cold store conditions.

The souring or ripening of the milk is generally accepted as the most essential process, and it is hardly necessary to state that for this purpose only pure cultures of lactic acid organisms are used.

The souring process itself is carried out in propagators, in which the process goes on continually. The sweet milk is run in at the top of the propagator as the equivalent amount of fully ripened milk leaves the plant. In this direction also our works have broken away from the old process of souring, when the milk was left to ripen in large open vats.

All these processes are governed by the strictest rules of hygiene and sanitation. Margarine, like butter, being a most delicate substance, and one which is very easily influenced by organisms such as bacteria and moulds, calls for the most careful treatment; further, as the milk offers the most ready ground for the development of such organisms, you will readily understand that the hygienic conditions in a margarine factory cannot be too highly rated. In fact, nothing less than the actual sterilisation of the utensils and raw materials will suffice, and there is a constant hunt for germs in every corner and every pipe. Live steam has proved to be the most effective, and in every respect the least harmful, method to adopt for sterilisation in a food factory.

In our margarine works at Southall we have gone so far in this direction as to instal expensive plant for purification of the air in the work-rooms. The plant is so constructed that the fresh air is drawn from shafts protruding high above the buildings, and is passed through a chamber where conditions of constant rain prevail. The water is distributed over the whole area of this chamber by means of hundreds of sprays which eject the water as a very fine rain. The passing of the air through this water frees it from dust and organisms and makes it clean and humid, like the atmosphere after heavy summer rain. Further, the plant contains heating and cooling elements which enable the air to be cooled in the summer and heated in the winter. By means of a system of air-ducts the treated air is distributed through the work-rooms. The result of this installation has been most satisfactory, and an atmosphere of constant humidity and temperature can be practically maintained throughout the year. It

has not only largely assisted us in raising the keeping quality of the margarine, but, although no statistics are available, we are of the opinion that it has raised the standard of health of the workers generally.

The raw materials for the margarine industries —*i.e.* copra, palm kernel and groundnuts—come chiefly from the British Empire, and in view of the prospective great shortage of butter and animal fats, caused by the depletion of European cattle stocks during the war, the future of British margarine manufacturers is assured, provided that they will turn out a satisfactory quality. To do this they must secure the best plant and raw materials and treat them under the expert guidance of the best chemists and scientific experts.

There is a great future before the products of British tropical Colonies, and we can look to them greatly to augment our food supplies and so help to counterbalance the shortage of animal fats.

Prior to the war most of the smaller British margarine manufacturers found it very difficult to compete successfully with the much larger Continental manufacturers.

It is naturally difficult or impossible successfully to establish an infant industry in Great Britain in opposition to old-established large and powerful Continental interests, who are determined to hold the trade and whose home market is fully or partly protected by tariffs. Maypole was able to do this only because they had very strong financial resources, and they owned their own retail distributing stores.

Although, thanks to the effects of the war, the British margarine manufacturers are now unlikely to require any protection, yet I suggest that our politicians should mutually agree to encourage the manufacture in the United Kingdom of foods and essential and important articles like aniline dyes, leather, etc., even when that encouragement may in some few cases necessitate temporary protection or a development grant for a few years, until the infant industry is firmly established, and sufficiently strong and experienced to bear the competition, fair and unfair, which powerful and protected Continental trusts can bring to bear on any British infant industries.

Once an industry is firmly established, the favourable conditions for manufacturing in the United Kingdom should render it independent of any permanent protection tariffs or development grants.

At Maypole's refining mills and margarine works we consider the laboratories to be one of the most important parts of the organisation, and no expense for research is spared there which will help towards future progress. I fear that in the past some British manufacturers have not attached so much importance to the expert and scientific assistance of their chemists and chemical engineers as their Continental competitors.

My experience in business convinces me that the industrial victories of the future will be won by those nations who encourage their home manufactures and scientific education, and whose manufacturers make the greatest use of chemical and scientific knowledge.

It will also be advisable to link closely together the interests of employers and employees by means of profit-sharing and co-partnership. The manufacturers who continue to rely on obsolete and old-fashioned "rule-of-thumb" methods, and neglect to secure efficiency and the interest and goodwill of their employees, are doomed to failure.

It is to be hoped that our public schools and universities will in the future give greater attention to the teaching of natural science and chemistry, even if this necessitates less attention to the teaching of Latin and Greek.

I should like to suggest the endowment of scholarships by manufacturers and others to enable the brightest scholars at our schools further to pursue their studies in this important subject.

I have dealt very fully with the manufacture of margarine, and before concluding my paper I should like to say a few words upon its distribution and the queues which have recently arisen during distribution, and for which Maypole have been thoughtlessly blamed.

Prior to the war about 75 per cent. of the margarine was distributed by the multiple shop companies, and sold by them at low prices very largely to the wage-earners in industrial centres. When butter became very scarce and dear everybody rushed to the multiple shop companies to buy margarine.

The demand soon exceeded the supply, and retailers, some of whom had not previously dealt in margarine, struggled to get supplies. The multiple shop companies endeavoured, by selling only a certain portion of the week's arrival each day, to reserve some for their old working-class customers who have to shop at the end of the week. Maypole was greatly blamed by the Islington and other food control committees for adopting this course,

but immediately they stopped it they were requested or ordered to reintroduce it by many other local food committees.

The growing shortage, combined with the practice of reserving supplies for the working-class customers, caused queues, and it was believed by some that the queue evil would be cured and the poor get their supplies by increasing the number of distributors.

The only real cure for queues was either to increase the supplies or compulsorily to lessen the demand, and secure equal share for everybody by the adoption of an individual rationing scheme. One of these courses is necessary whenever an essential food is in short supply, and a maximum price is therefore imposed and conditional sales are forbidden.

The fact that conditional sales were allowed with sugar in 1916 misled our politicians, and apparently made them think that individual rationing of an article in short supply was not necessary, and that they could safely "wait and see."

When the Food Ministry did commence to ration, they, in the first place, rationed the wholesaler and the retailer instead of the consumer.

Some local food committees have now commenced to ration the consumer, but it is probable that difficulties will arise if they continue to bind each consumer to a particular retailer, as this will increase cost to consumers, sacrifice freedom, and involve immense detail labour and responsibility on officials for the stocks and supplies to each individual retailer. It may be practicable to bind a consumer to a particular retailer for dry goods, but I fear it will be very difficult with perishable articles like margarine and meat.

In my opinion rationed goods should be obtainable on presentation of a card with detachable coupon at any retailer in the food area, who should be bound to sell if he has them in stock. This would be practicable, and queues would also be prevented if the total demand in each district was, by the use of these cards and detachable coupons, compulsorily kept below the known total supply.

It may soon be found necessary to introduce a national individual scheme of rationing, as it is improbable that the Ministry of Food can continue to control or co-ordinate the many different schemes put in operation by the local food committees.

Some of these local food committees recognised what they owed to Maypole for their supplies of margarine, and gave them consideration; but others made things very difficult. For example:—

Halifax, Sowerby Bridge, and many other local food committees, ordered Maypole to cease retailing margarine, and only allowed sugar retailers to sell margarine. Maypole were not allowed to sell sugar, so they were put out of the retail margarine business in many towns.

Wellingboro' local food committee ordered Maypole to advance their retail price from 11*d.* to 1*s.* per lb., and to cease selling to all their old customers and only serve members of the co-operative society whose names commenced with A, B, or C.

In some towns the local food committees ordered Maypole to advance their prices for margarine to consumers, and then transferred part of Maypole margarine to a co-operative society who give dividends on purchases, and so made their net price below the obligatory price at which Maypole were made to sell it.

Many retailers to whom Maypole margarine was transferred had never previously sold margarine, others made a condition and refused to supply margarine to those who were not registered with them for sugar or a member of their co-operative society.

Maypole shops were open to all, including those to whom sugar retailers would not or could not supply margarine. Maypole had no right to make a condition or to refuse to supply anybody, so they were powerless to prevent queues in the absence of an individual rationing scheme.

Meat is now in short supply, so the cash butchers who sell cheaply and supply the working-classes will be the innocent cause of queues until the introduction of an individual rationing scheme to secure an equal share to everybody.

It is a pity that the authorities failed promptly to recognise that the queues are a symptom rather than a disease, and it is therefore more necessary to remove the cause than to disperse the effect.

It would have been in the interests of the poorer consumers if a national individual rationing scheme had been prepared in good time, and adopted immediately supplies were short; the distributing business could then have remained in the hands of those who have proved their ability to distribute efficiently and economically.

Until quite recently Maypole distributed

their make of margarine at 11*d.* per pound, but under the new conditions prices must be higher, and there will be waste and losses in hot weather, owing to the low melting-point of nut margarine. Nut margarine, like fish, is unsuitable for distribution at many small shops during hot weather.

If some members of the public still mistakenly believe that Maypole is blameworthy and responsible for the short supply of margarine and the consequent queues, I hope that those who are present to-day will form a different opinion.

Maypole can only plead guilty to two things:—

Spending over £500,000 upon buildings and machinery (double pre-war prices) to enable them to increase the production of British margarine.

Distributing margarine to consumers at low prices and free from all conditions. They sold cheaply by the express wish of the Government. They only advanced their retail price when requested or ordered to do so by many local food committees.

Maypole is not deserving of either criticism or punishment, and they therefore severely felt the injustice of being made the scapegoats for the effects of the margarine shortage.

In conclusion, I should like to thank you for the patience with which you have listened to me and at the same time I crave your indulgence for troubling you with this defence of the good name of my company. It is still permissible to defend one's honour and good name, although all private financial interests must now be made subservient to the national interests.

I hope that my paper will help to prove the necessity of encouraging the study of science and chemistry, and the advisability of giving support to the home production of margarine and other important foods, and so render them less vulnerable to the submarines of our enemies.

DISCUSSION.

The Chairman (Sir Arthur D. Steel-Maitland, Bt., M.P.), in opening the discussion, said that in so far as the paper was a defence of the good name of the Maypole Company, he was sure that no such defence was really needed, for it was well known that that company, and all other makers of margarine, had done their best to produce margarine to their utmost capacity as supplies and prevailing conditions permitted. The problems in connection with the manufacture of margarine formed an epitome of all the various kinds of problems with which Great Britain was faced at the present moment, and would be faced after the war. For instance, at the outbreak of the war this country was placed in a position, which was absolutely unnecessary, of dependence on foreign supplies for some essential articles, and she was in that state of dependence in a great measure with regard to margarine. There was really no reason on any economic grounds why this country should not have produced margarine just as much as those countries which were our chief suppliers; but different firms in the same line of business, or in connected businesses, did not stand together in this country as they did on the Continent. The reason why margarine manufacture became established to a large extent on the Continent was because there was a distinct organic interconnection there between the firms that carried out the various processes of refining and marketing, etc. That again was an instance of another problem which would face this country after the war; and he desired to emphasise the fact that if this country wished to be in a position to face competition in the future, its people would have to realise that under modern conditions industries had got to work in organic relation with one another, instead of as a number of separate, and very often warring, independent units. When one began to go into the question of oils and fats, of which the subject of margarine formed part, one saw how complicated the industry was. There were eight or ten principal oils and fats imported into this country—linseed, cotton seed, soya beans, coconut oil, palm-kernel oil, tallow, whale oil, stearin, etc.—and when one came to deal with the question of providing them methodically, instead of allowing them to come in according to supply and demand, it was found that while two or more than two might be interchangeable for any one purpose, those which were interchangeable for one purpose were not interchangeable for another purpose. For instance, most of them could be used for making soap, but only some could be used for edible purposes. Before margarine could be made, the raw material had to come to this country in the form, say, of palm kernels, which had to be crushed to obtain the oil from them. Then that oil had to be refined, and after that machinery was required for making it into margarine. At any moment at any one of those stages there might be a hitch in the course of manufacture. For instance, we had not been accustomed in this country to use palm kernels to any great extent before the war, and they required a different kind of machinery to crush them economically from that required for crushing other oil seeds, the result being that we were held up for some time because we had not got that particular kind of crushing machinery. Then again, with regard to refining, at first only certain kinds of oils and fats were thought fit for human food, but by degrees new processes of refining and hardening oils made certain types of oils fit to eat which were not thought suitable before. He had

personally tasted refined and hardened whale oil, which had been coming into use on the Continent for making margarine, although it had not yet been used in this country, and he did not think it was so good as other oils, he could quite believe that it would become so in course of time. The subject of margarine not only was an instance of the quite unnecessary reliance placed by this country on foreign supplies before the war, but it also illustrated the problem with regard to raw materials with which we should be faced at the end of the war. There were, of course, many controversial questions connected with the adequate supply of raw materials after the war, and the subject of oils and fats was one of the most interesting of them, both as regards the supply for our own country and the degree of dependence of Germany on other countries for her supply. In a little book he had just published, called "The Staple Trades of the Empire," he had given a chart showing the main sources of oil throughout the world. It was interesting to note the vast proportion of oils that was produced within the British Empire and the United States. There was a large amount of linseed oil produced in the Argentine, and a great deal of coconut oil produced in the Dutch East Indies, but the greatest production of cotton-seed oil was in the United States; and our African Colonies, India, and, to a certain extent, Ceylon and our Pacific Colonies, produced a very large amount of palm-kernel oil, palm oil, groundnut oil, rape-seed oil, millet, and cotton-seed oil. The German dependence on imported oils before the war was very considerable. He had just made a rough calculation, and found that Germany imported in the year 1913 oil seeds and nuts containing an oil content of just under 600,000 tons, whereas the importations into this country were certainly not two-thirds of that amount, the oil content of the seeds and nuts imported being probably about 380,000 tons. It had to be remembered, however, that, although Germany was dependent to a large extent on foreign supplies, there was a considerable amount of oil seeds and nuts produced in parts of the world outside the Allied control. With regard to the subject of raw materials, the main points to be considered were who had the control in the country of production; would the total supply in the country of production be equal to, or greater than, or less than, the probable demand of the world as a whole; were there substitutes which could be used by Germany in place of articles grown in Allied countries, if those were denied to her; and, lastly, what would be the carrying position at the end of the war, and to what degree was it likely to suffice for the goods that were to be carried. He thought the question of oils and fats was a most interesting illustration of the whole of the problems that would confront this country after the war.

Mr. D. F. Shillington desired to thank the author for his very interesting and illuminating paper, and also to thank the Chairman for his remarks upon edible oils. As to the question of queues, which had been referred to, he would like to suggest that if the author would arrange that at the many branches of his company every person should be supplied with the same quantity of margarine, and that it should be sent from the factory done up in parcels of, say, 1 lb. each, and that every customer should come to the shop with the exact amount of money he had to pay, then there need be no queues. A great deal of time was at present taken up in weighing the margarine, making it up into parcels, and giving change to the customers.

Mr. J. H. Coste said that, with regard to the author's remarks as to the equal value of animal and vegetable fats, Dr. Halliburton had shown, in a paper published in the *Journal of Physiology*, that for the growing animal vegetable fats were not equivalent in value to animal fats, because they were deficient in growth-producing substances. Of course, under normal conditions the human child did not depend on margarine alone for its supplies of fat; but as some such conditions might come about, he thought the question he had mentioned was worthy of consideration.

Mr. J. E. Trigge (Niger Company) said he did not think cheap margarine was an unmixed advantage at the present juncture. During the last few months, before the position became acute and the shortage of margarine very pronounced, in many places there was a larger consumption of margarine, butter, and other fats than in ordinary times, which had helped to bring about the present shortage. When margarine could be obtained cheaply the consumption was increased, and supplies had to be brought from abroad to meet the demand. Germany was not altogether to blame for our present shortage of supplies of fat because before the war we had neglected the matter, and were now suffering for our neglect. Twenty-five years ago the speaker's company introduced a new fat into this country for edible purposes, but no one would use it, and consequently he was instructed to take it abroad and introduce it there.

Mr. S. Barnett thought that one good feature of the author's company was its system of profit-sharing. In any up-to-date manufacture in the future some system of profit-sharing would have to be employed if that co-operation between capital and labour which everyone hoped to see after the war was to be achieved. Before he became a manufacturer he had been for fifteen years engaged in the distribution of all kinds of food on a somewhat large scale, and he had no hesitation in saying that this country was now paying the penalty of her policy of neglect in the past. He thought this country was greatly indebted to

anyone who increased the home production and manufacture of food. From his experience as a food distributor, he knew the difficulties which had confronted the author's company and others that had shown enterprise, and the very scanty encouragement they had received from the traders and from the general public in this country. He did not think the Maypole Company would have found a market for the quantity of goods they were manufacturing if they had not had their own distributing shops, and had not begun to manufacture after they had possession of the channels for distributing. One great advantage which this country had derived from the enterprise of the Maypole Company was that the manufacture of 2,000 tons per week of margarine involved the production of an immense quantity of other materials, such, for example, as material which was made into feeding-stuffs for cattle. Margarine manufacturers not only produced margarine but also provided material at a reasonable price which would otherwise have to be imported, and in producing margarine they also helped to produce beef.

Mr. C. Revis said that the author had referred to the necessity of manufacturers employing scientific assistance, and that was a matter which had been greatly neglected by manufacturers in this country in the past. British chemists believed that lessons taught by the war were going to be of great assistance to them. They had responded well to the demands which the present necessities of the country were making upon them, and it was certain that if British manufacturers were going to hold their own in the future they must turn to the scientific men for assistance, as other countries had done.

Sir William George Watson, in reply, agreed with the remarks made by Mr. Revis with reference to manufacturers employing chemists, and said that those chemists should be given seats on the board of directors, as was the case in the Maypole Company, so that they could become fully acquainted with all the details of the business. With regard to Mr. Shillington's suggestions for the abolition of queues, the Maypole Company had already tried the plan of distributing margarine to their City shops in one pound and half-pound parcels, and there the queues had, strangely enough, been worse than anywhere else. As a matter of fact, when a business was doing a cash trade and did not know its customers, and when the demand was in excess of the supply, there were bound to be queues. Many people seemed to think that manufacturers should not be also distributors, but people who were both large manufacturers and large distributors could supply their products at a low cost to the consumer; and British goods, when sold in competition with foreign ones, would only be bought if their quality and price compared favourably with the foreign products. With regard to margarine made from vegetable fats being deficient in growth-producing substances, his company had taken the necessary steps to have the matter investigated.

The Chairman, in proposing a hearty vote of thanks to the author for his interesting paper, said that, with reference to Mr. Trigge's suggestion, he did not think that the shortage of margarine was due to any great extent to the increased consumption in this country, although there had for various reasons been a bigger demand during the war. If anything, our supplies were less now than they previously were. The home production of margarine had, of course, enormously increased, and was now three times as large as it was before the war. But what had to be compared were the home supplies of margarine, the home production of butter, the importations of margarine, and the importations of butter; and it was the importations of butter, which had fallen off so very largely, and the fluctuation in the supplies of foreign margarine, which had diminished our total supply of fats. What this country had gained in the home production of margarine it had lost very largely in decreased importations, and it was probable also that the home production of butter had fallen a very great deal. As regards the employment of scientists by manufacturers, he though the use of science in commerce would have to be much greater after the war than it had been before. Manufacturers should not only go to a chemist to obtain his advice on certain points, but they should employ chemists permanently, and let them have an influence on the whole conduct and management of the works.

The vote of thanks was carried, and the meeting terminated.

AMERICAN POTASH.

The production of potash in the United States was greatly increased in 1916, according to a report of the United States Geological Survey. The total production of potash salts and potash products in the United States in 1916 represented about 10,000 short tons of pure potash, with a net value at point of shipment of at least $3,500,000. This is ten times the value of the production reported for 1915, but the figures submitted by many of the producers represent only a start made towards the end of 1916.

The potash produced in 1916 was derived from the following sources:—

Mineral sources.—Natural salts or brines, 3,850 short tons; alunite and silicate rocks (including furnace dust recoveries), 1,900 short tons.

Organic sources.—Kelp, 1,100 short tons; pearl-ash (mostly from hardwood ash), 220 short tons; miscellaneous industrial wastes, 1,750 short tons.

The largest output comes from the Nebraska alkali lakes, but the natural saline deposits else-

where are beginning to make important contributions. The production of potash from organic sources is about half that from mineral sources. The recovery of potash from pearlash is an old-established industry.

PRODUCTION OF BEESWAX IN BRITISH EAST AFRICA.

The gathering of beeswax in the East Africa Protectorate is almost entirely in the hands of the natives, who obtain the product from wild hives in the country. Very little scientific apiculture is practised, and that only by the European settlers in the highlands. Notwithstanding the present small production of honey and beeswax, writes the United States Consul at Mombasa, the higher altitudes of the Colony are peculiarly well adapted to apiculture. Clover is an abundant crop, and other flowers are plentiful. There are two rainy seasons, no winters, and so far no serious bee diseases have developed. The Government is giving every encouragement to the industry, and the active interest of the settlers is being aroused to the opportunity. It is believed that the near future will witness a substantial development in this industry.

During the fiscal year ended March 31st, 1915, the total export of beeswax amounted to 1,563 cwt., valued at £10,000, of which Germany took 50 per cent., France 15 per cent., the United Kingdom 14 per cent., Belgium 11 per cent., the remainder going to Italy and Holland. For export, the product is packed in bags containing 5 frasilas (180 lb.). There is no export duty. The import duty on beekeeping supplies is 10 per cent. *ad valorem*, the value for customs purposes being based on the c.i.f. Mombasa cost (amount of invoice plus freight and shipping charges). There are no statistics available as to the amount of importation of these supplies.

CHEMICAL INDUSTRY AND PATENT LAW.

A paper on the above subject was recently read before the Society of Chemical Industry by Dr. F. W. Hay, of British Dyes Limited. The author expressed himself on the following lines:—

In view of tho fact that the prosperity of the country depends so largely on industrial activity, and that no industry can maintain its reputation in the markets of the world without constant improvement, the question whether the inventive talent of the people is stimulated and assisted in every respect is a matter of primary importance. We have a fairly highly developed patent system in this country, which is, in fact, the oldest of its kind. In its fundamental conceptions it has been incorporated in the Statute Law of almost all other countries. Its governing principle dates back to the Statute of Monopolies of 1623, and is still on a sound basis, but it has never been made to produce its full beneficial effect.

According to this governing principle of our Patent Law, a patent, in order to be valid, should cover a new invention. The Patent Office, however, owing to the inadequate system of preliminary examination allotted to it by the Act of 1902, merely examines whether the invention to be covered by a patent is new with regard to prior British patents of the last fifty years. These British patents only represent a fraction of the industrial development that has taken place, as so many discoveries are made in other countries. Owing to this very incomplete system of examination, patents issued in this country cannot be considered to contain any reliable evidence of novelty. Those that are granted for genuine inventions are inundated by a large proportion of patents delivered for inventions that are new only as far as prior British patents are concerned, but are not in fact entirely new. The law, however, stipulates, and rightly so, that the invention should be new in every respect: hence a serious anomaly exists between the attitude of the Courts, which consider all prior publications, and that of the Patent Office, which examines prior British patents only. A patent sealed by the Patent Office is therefore liable to be upset in Court on the grounds of anticipation as soon as it is issued. The inventor finds it exceedingly difficult to introduce his invention owing to the lack of consideration given to patents in this country, and the manufacturer is deterred from using a new invention, because the patent he is offered may or may not be a valid instrument of defence against infringers.

It does not seem expedient to leave the novelty of the invention to be determined by the Courts. The novelty of all inventions to be protected by patents should be investigated by the Patent Office by means of a *general system of examination*, covering all prior British and foreign publications. Without demanding any particular standard of novelty, or applying the criterion of a "new practical effect" adopted in Germany, patents should be granted only for inventions that contain some novel feature over and above the inventions disclosed in the prior publications. All other applications for patents should be refused.

Specifications relating to chemical industry, and describing an invention which seems problematical or obscured by irrelevant or misleading statements, might in certain cases be verified in suitable Government laboratories, so as to avoid the delivery of patents that are intended to obstruct. The supply of samples is deemed insufficient for this purpose. As an alternative, the system of granting patents recently adopted in Switzerland might be found

an effective measure against the delivery of obstructive patents.

The public should be allowed five years within which the patent could be revoked on the grounds of anticipation, inadequate description or prior use, and the validity of the patent should then no longer be open to attack in Court, so as to give greater security to any new manufacture depending on patent rights.

The Courts find great difficulty in dealing with litigation relating to chemical industry, and frequently fall into serious scientific error. The judge has to rely on expert evidence which he is unable to understand, because years of scientific training are required to be able to cope with the highly technical evidence brought forward. No demonstration *ad oculos* can, as a rule, be made. Great uncertainty, therefore, prevails with regard to patent litigation relating to chemical manufacture, and even wealthy companies often prefer to put up with a certain amount of infringement rather than defend their rights. It is therefore proposed that all actions in Court connected with infringement of patent rights, should be tried in the presence of a "Technical Jury," consisting of experts engaged in the industry or science to which the action relates and assembled in the manner of a "Special Jury."

FORESTRY WORK IN NEW ZEALAND.

The principal Government forestry nursery and reserve of New Zealand is at Rotorua. Mr. H. A. Goudie, General Superintendent for the North Island, has given the United States Consul-General at Auckland an opportunity to study the nursery and plantation, where the first forestry work was begun in 1898. Since that date, writes the Consul-General, 58,459,000 forest trees had been propagated in this nursery up to March 31st, 1916, out of a total of 104,835,900 for the entire Dominion since the beginning of the industry; and more than 14,700 acres of trees had been planted on the two adjoining reserves, out of a total of 27,228 acres for the Dominion.

The soil for the nursery is thoroughly prepared by being cultivated and fertilised until it becomes a rich, black sandy loam before planting is begun. It is then laid out in beds about 8 ft. wide, and 100 ft. long, into which seeds for about 200,000 plants each are sown. A very great majority of the plants are cultivated until they are two years old, when they are transferred to the plantations, or sold to individual growers at the cost of production. The output of the nursery for the past few years has varied from 2,600,000 to 6,000,000 plants.

Only eight Government forest plantations of any importance are maintained in New Zealand. The largest two are just south of Rotorua, and cover more than 21,000 acres. About two-thirds of this area has been planted with trees averaging 32 square feet to the tree. The work is thoroughly done, and it is calculated that at the end of thirty years some good saw logs may profitably be cut from the eucalypts and the more rapidly growing pine forests. Meanwhile, many trees which are cut to thin out the timber may be used for poles, posts, sleepers, etc., while a considerable quantity of firewood is sold annually from the plantations. The total cost of the plantations to March 31st, 1916, had been £224,000.

Tests have been made with many different species and classes, with a view to determining what timber can be most advantageously grown in New Zealand, with the following selections:—

General building construction (scantling, weatherboards, etc.): Corsican pine, heavy pine, Weymouth pine, Monterey pine, Douglas fir and eucalypts.

Joinery (doors, windows, etc.): Weymouth pine and Douglas fir.

Flooring, lining, and interior finish: Any of the kinds in the two preceding groups.

Bridge-building and similar heavy construction: Eucalpyts, Douglas fir, and Corsican pine.

Coach-building: Eucalypts for framing, Corsican pine, heavy pine, Weymouth pine and Douglas fir for boards and panels.

Railway ties, telegraph poles, and fencing: Eucalypts.

Packing cases, kegs, and butter boxes: Any of the pines mentioned in preceding groups, and, in addition, sweet chestnut and poplar.

Boat-building: Eucalypts, Douglas fir, Corsican and heavy pines and larch.

Turnery: Eucalypts, ash, oak, chestnut, poplar, and pines.

Furniture: Eucalypts, sweet chestnut, Weymouth pine, Douglas fir, poplar, ash and oak.

The best results are obtained from American pines and the Australian eucalypts. Many European larch trees were planted several years ago, but with unsatisfactory results. During the year ended March 31st, 1916, much less work than usual was done in Government forestry. In 1916–17, however, there were 5,848,930 forest trees raised at the four State nurseries in New Zealand, and 5,419,569 trees were planted in the eight Government plantations, covering 2,764 acres. The total area planted since the start of operations in 1896 thus amounts to 29,992 acres. Enough seeds have been ordered from France and America for sowing next spring to produce 2,500,000 trees, to be used at the Rotorua nursery alone.

It is estimated that at the end of thirty years the native forests of New Zealand will have been exhausted. The annual consumption of lumber will then require the cut from at least 20,000 acres of timber lands, which means that about that area must be planted annually if the supply is to be provided by the Dominion.

In this the general public is beginning to realise that it can materially help by planting small patches on farms and along partition fences, and the Government proposes to supply the young trees at cost.

ENGINEERING NOTES.

Caproni Flying Machines.—At a recent interview with Reuter's correspondent, the brothers Caproni, the celebrated designers and builders of Caproni aircraft, says *Chambers's Journal*, expressed a belief that, after the war, lines of aircraft will run between various towns and countries, the machines being luxuriously fitted with accommodation for one hundred or more passengers, where the speed will range up to one hundred and ninety miles an hour. They advocate aeroplanes with two or three motors of 300 to 500 h.p. each, as the adoption of several engines forms a guarantee of safety. These authorities also predict the construction of aeroplanes for service between Europe and America, having accommodation for fifty or sixty passengers, immediately after the war, and they point out that Caproni triplanes are also capable of carrying thirty passengers between Milan and Turin. The foregoing predictions are supported by the statement, on good authority, in *Aviation*, that an aeroplane is being built in Italy with motors of 3,000 h.p. which is designed to carry fifty passengers.

Trinitro-toluol as Substitute for Dynamite.—Many by-product coke plants in America are already engaged in recovering quantities of trinitrotoluol for manufacturing munitions, and many plants which will recover this explosive are being erected. Its superiority to picric acid was plainly demonstrated early in the war. It is now a question, according to Mr. M. A. Allen, writing in the *Mining and Scientific Press*, U.S.A., of November 10th, whether the trinitro-toluol which is recovered by these plants cannot be put on the market in competition with dynamite as a commercial explosive after the war. On the face of the matter, trinitro-toluol is a much more desirable commercial explosive than nitro-glycerine. It does not freeze, does not melt until a temperature of 81° C. is reached, does not ignite until a temperature of 300° C. is reached, and even then does not explode, does not give off the slightly volatile gases which produce severe headache when dynamite is handled, and does not deteriorate under water. The only serious objection to its use is that the explosion produces a large volume of carbon-monoxide gas. However, this is also the case with nitro-glycerine, and dynamites used for tunnel driving are mixed with nitrate as an oxidizer to prevent the formation of this gas. The same thing could, of course, be done with trinitrotoluol. Apparently the chief thing remaining to be worked out is the process of putting the explosive up in convenient form for handling, as is done with nitro-glycerine in dynamite sticks.

Titanium.—It is just announced that there has been a big discovery of titanium in Korea, where the Governor-General has been engaged for some time in the investigation of the mineral resources of the peninsula and the collection of samples of tungsten ore produced in the colony. While examining the various samples of tungsten ore, says the *Indian and Eastern Engineer*, experts discovered a vein of this rare mineral. The newly discovered titanium mine is located in a mountain district of Kanguon-To, not very far distant from Seoul. It has quite rich veins, and, in the opinion of experts, can furnish ample supplies of the rare mineral for industrial purposes. A number of uses have been discovered in the United States for this mineral. By mixing with steel, the hardness of the metal is wonderfully increased. A slight addition of carbon may increase the elasticity of the compound. Thus manufacturers of rails, cutlery, springs, and other articles, have found it an indispensable material for them. In Japan the mineral has been discovered in several places, but it has formed no large deposits available for industrial purposes. It is said that the present discovery in Korea will prove a great help for industrial workers, enabling them to produce certain kinds of steel materials now imported from America.

Arch Dam of Sharp Radius in New Mexico.—One of the shortest radius arch dams for its height yet built is nearing completion on the Cimarron River, New Mexico. The Eagle's Nest dam is 140 ft. high, 30 ft. of which is below the river bed, and has a radius of 155 ft. It is 8 ft. wide at the top and 46 ft. at the base. It drains the Moreno Valley, in Colfax County, at a point where a red granite and porphyry dike, forming a prehistoric lake, has been cut through. The cañon is therefore narrow—40 ft. at the base of the dam and 300 ft. at the crest. The project is to impound 80,000 acre-ft. in the remade lake, to irrigate 30,000 acres. As the dam is 6,000 ft. above sea-level, the season is short, and construction must be carried on from April to October inclusive. Concrete is prepared in a central plant located at the down-stream toe, below a crushing and screening outfit. The spillway at the north end is in a granite saddle of the rock. It will have a length of 50 ft. and a depth below crest of 7 ft., giving, with 1 ft. freeboard, a capacity of 350 sec.-ft., which is in excess of the maximum flood recorded. The outlet tunnel through the rock at the south end has four inlets, at different elevations, leading into the gate-control shaft. The above particulars are abstracted from the *Engineering News Record*.

London Tube Railways.—It is, perhaps, not generally known that the late Sir John Wolfe-Barry was a vigorous opponent of the tubes, with their cost and annual lift and ventilating working expenses, and their absence of the facilities for access to platforms and for through traffic to or from the

suburbs. The tubes constructed since, owing, no doubt, to the same disadvantages, have been condemned in New York, Paris, Buenos Aires, Sydney, and other cities. The objection, *per contra*, that the sewers, water and gas pipes, etc., would be interfered with, has been successfully surmounted by Sir John himself, who was engaged in the construction of the Metropolitan and Metropolitan District Railways, and ought, presumably, to know.

Canal Motor Boat.—Recently an interesting trial trip was carried out on the Birmingham Canal with a monkey-barge which had been converted to power by the fitting of a detachable paraffin motor. The motor employed was a four-cylinder Sterling engine, developing 17 brake-h.p. at 600 revolutions per minute, and geared down 25 per cent. to increase the propeller efficiency. It was mounted aft on the raised cabin-top, and the power is transmitted to the vertical shaft, which takes the line of the sternpost, through two shafts, one of which is hollow and arranged to telescope into the other. These telescopic shafts are necessary, in order to allow for the varying distances between the engine and the vertical propeller shaft when the propeller attachment is put hard over to port or starboard for steering. There is a universal joint fitted, of course, at each end of the transmission shaft. This does away with any need for engine alignment, which is a necessary point in a portable equipment that is intended for service on different boats. As is customary in most outboard sets, the propeller swings round with the rudders, which has the effect of making the vessel quick on her helm, a noteworthy feature in a barge employed solely on inland water transport. The trials, it appears, were very successful: the apparatus proved itself not only capable of driving the barge on load draught at a fair speed, but it could easily take in tow two other loaded barges, making a total of about 100 tons deadweight. The initial cost is also comparatively small, as one equipment can easily serve a number of barges.

OBITUARY.

ALFRED DE ROTHSCHILD, C.V.O.—The death of Mr. Alfred Charles de Rothschild occurred at his town house, 1, Seamore Place, Mayfair, on January 31st. The second son of Baron Lionel Nathan de Rothschild, M.P.—the first Jew elected to the House of Commons—he was born in 1842, and educated at King's College School and Trinity College, Cambridge. He was associated with his brothers Nathan (afterwards Lord Rothschild) and Leopold as a partner in the firm of Messrs. N. M. Rothschild and Sons. He was also for more than twenty years a director of the Bank of England, and, until the war, Austro-Hungarian Consul-General. Lord Rothschild died in 1915 and Mr. Leopold de Rothschild in 1917. All three were Fellows of the Royal Society of Arts, and one of them, Lord Rothschild, was for some time a member of the Council. A man of cultivated taste, Mr. Alfred de Rothschild published for private circulation two volumes, with illustrations and descriptions, of his valuable art possessions. He was a trustee of the National Gallery and of the Wallace Collection. Last year he placed at the disposal of the Prime Minister, "for the benefit of the country," the woods on his Halton estate in Hertfordshire, 500 acres of which were planted with birch. He held the Legion d'Honneur, and had been a Commander of the Royal Victorian Order since 1902.

GENERAL NOTES.

THE MINERAL OIL RESOURCES IN THE BRITISH EMPIRE.—Some interesting facts about the production of mineral oil within the British Empire were given by Professor J. S. S. Brame, of the Royal Naval College, in a recent lecture before the London School of Economics. In the present circumstances such sources are specially valuable, as being less liable to interruption than those in foreign regions. By far the most important source of supply is Burma, which furnishes nearly three million gallons per annum. Assam and the Punjab also afford useful contributions, while among other regions may be mentioned Taranaki in New Zealand, Trinidad and Barbados, Canada, Egypt, Sarawak and British North Borneo. In Canada the output has unfortunately diminished during recent years. Within the United Kingdom the Scottish shale-oil industry is an important asset, and further possible sources in Norfolk and elsewhere are being examined. There are vast latent possibilities in the distillation of oil from the tar-fields of Athabasca, which extend over thousands of miles, and probably contain enough oil to last the world for 2,000 years. When the country is more fully developed, better transport facilities are available, and the cost of extraction can be reduced, these deposits may prove a very valuable asset to the Empire. At present, however, only about 3 per cent. of the world's production of mineral oil comes from the British Colonies and Dominions.

BANK MEETINGS.—Sir Edward H. Holden, at the annual general meeting of the shareholders in the London City & Midland Bank, Ltd., gave an interesting account of Germany's pre-war financial methods and banking law. He followed this up with an analysis of the financial position of the United States of America, and a description of the financing of the two "Liberty Loans." Out of these the United States Treasury arranged between April and December 31st, 1917, the following loans for the Allies: to Great Britain, £409,000,000; France, £257,000,000; Italy, £100,000,000; Russia,

£65,000,000; Belgium, £15,480,000; Serbia, £800,000; making a total of £847,280,000.—Mr. Walter Leaf (chairman), presiding at the annual general meeting of the London County and Westminster Bank, said that the shareholders had probably heard fears in some quarters that the great increase in Bank resources might form a strong temptation to the Chancellor of the Exchequer to help himself in some emergency by commandeering bank balances. That was not, in his opinion, a risk which deserved any attention. The Chancellor could gain nothing by such an operation, because he had got the whole increase already by a voluntary process. When they considered that the increase in cash at call and short notice was mainly lent to the Government through the Bank of England; that the great increase in bills discounted had gone direct into the Chancellor's hands in the form of Treasury Bills; and that the increase in advances had done so indirectly through the bank's customers' investments in War Loan, the shareholders would see that if he attempted to call upon the bank for anything in the way of a forced loan, it would not be possible for it to meet such a requisition except by taking from him with one hand what he was asking the bank to give with the other.

THE RÖNTGEN SOCIETY.—At the meeting of the Röntgen Society, held on January 1st, Mr. Carl Darnell read two papers communicated by Dr. Coolidge, of the General Electric Co.'s Research Laboratories, U.S.A. The first dealt with a new form of Coolidge tube, in which the anticathode consists of a block of copper faced with a small button of tungsten. This is fixed to a thick stem of copper which passes out through the glass neck of the tube, and terminates in a fin radiator. The anticathode is thus kept cool, and does not in consequence emit electrons, as in the case of the earlier Coolidge tube in which the whole of the anticathode speedily becomes red hot. The new tube, therefore, so completely rectifies current that when an alternating potential is applied only one phase of the current will pass. In the second paper, by Dr. Coolidge and Mr. Moore, the portable field X-ray outfit of the United States Army was described. A petrol electric unit supplies alternating current at 110 volts to a transformer arranged to give both high tension and heating currents for the new radiator type of Coolidge tube. For simplicity of control the tube is worked at a constant potential of 5-in. equivalent spark-gap, and the current is adjusted to 5 milliamperes for continuous running of the tube or 10 milliamperes for short periods. An electrically-actuated control on the throttle of the engine maintains constant output. The small size of the tube—3½ in. in diameter—enables a close-fitting lead-glass shield to be employed; this is made in two parts, and completely surrounds the tube, a suitable aperture permitting egress of the rays.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

FEBRUARY 13.—LORD LEVERHULME, "The Relations between Capital and Labour — Reasonable Hours, Co-partnership, and Efficiency."

FEBRUARY 20.—MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." SIR ASTON WEBB, K.C.V.O., C.B., R.A., F.S.A., F.R.I.B.A., will preside.

FEBRUARY 27.—SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

MARCH 6.—A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

MARCH 13.—PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] The ARCHBISHOP OF CANTERBURY will preside.

MARCH 20.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

Dates to be hereafter announced:—

MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War."

MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

PERCY SHUTTLEWOOD, Ministry of Food, "The Food Situation in Germany."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

FEBRUARY 14. — SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces, "The Indian Hide and Leather Trade." The RIGHT HON. LORD ISLINGTON, G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

MARCH 14.—

APRIL 18.—ALFRED DICKINSON, M.Inst. C.E., "Water Power in India."

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

MARCH 5. — GEORGE YOUNG, M.V.O., ex-Secretary of Legation, Lisbon, "Portugal as a Colonial Power."

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912-17, "British Guiana."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced):—

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." Three Lectures.

February 18, 25, March 4.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEBRUARY 11 ... Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Presidential address by Mr. W. B. Esson.

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Mr. H. S. L. Polak, "Indian Labour Emigration within the Empire."

Geographical Society, Burlington-gardens, W., 8.30 p.m. Sir Aston Webb, "The London Society's Map with its Proposals for the Improvement of London."

Electrical Engineers, Institution of (Local Section), Mining Institute, Newcastle, 6.45 p.m. Mr. F. G. C. Baldwin, "Telephone Exchange Transfers and their Organisation."

TUESDAY, FEBRUARY 12...Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Staff Sergeant-Major A. M. Wright, "Some Applications of Chemistry to the Frozen Meat Industry."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 6.30 p.m. Mr. T. J. Norman, "The Decorations and Furniture of the Royal Palaces."

Asiatic Society, 22, Albemarle-street, W., 4 p.m. Mr. R. G. Brown, "The Drama in Burma."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "The Problems of British Anthropology." (Lecture II.)

Electrical Engineers, Institution of (Local Section), 17, Albert-square, Manchester, 7 p.m. Professor E. W. Marchant, "Some Transient Phenomena in Electrical Supply Systems."

(Scottish Section.) 207, Bath-street, Glasgow, 7 p.m. Professor M. Maclean, "Kelvin as a Teacher."

(Yorkshire Section.) Philosophical Hall, Leeds, 7 p.m. Mr. E. C. McKinnon, "Large Batteries for Power Purposes."

WEDNESDAY, FEBRUARY 13...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Lord Leverhulme, "The Relations between Capital and Labour—Reasonable Hours—Co-partnership and Efficiency."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. E. A. Savage, "The Utilisation of the Data of the Automobile Industry through Bureaux of Information."

Biblical Archæology, Society of, 37, Great Russell-street, W.C., 4.30 p.m. Mr. W. L. Nash, "The Origin of the Mediæval representations of Weighing the Soul after Death."

Japan Society, 20, Hanover-square, W., 3.30 p.m. Admiral Sir E. R. Fremantle, "Reminiscences of Japan."

Colonial Institute, Caxton Hall, Westminster, S.W., 8.30 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Sir Arthur Newsholme, "The Problem of Tuberculosis under War and After-War Conditions."

THURSDAY, FEBRUARY 14...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Sir Henry Ledgard, "The Indian Hide and Leather Trade."

Royal Society, Burlington House, W., 4.30 p.m.

Faraday Society, Municipal School of Technology, Whitworth-street, Manchester, 7 p.m. Conference on "Electric Furnaces."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. E. Gosse, "Three French Moralists, and their Influence on the War—La Rochefoucauld." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.30 p.m. Mr. J. R. H. Weaver, "More about the Photography of Architecture."

Optical Society, at the Imperial College of Science, South Kensington, S.W., 8 p.m. 1. Annual Meeting. 2. Naval Instructor T. Y. Baker, "Reflecting Prisms."

Historical Society, 22, Russell-square, W.C., 5 p.m.

FRIDAY, FEBRUARY 15...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor E. H. Starling, "The Mechanism of the Heart."

Geological Society, Burlington House, W., 5.30 p.m. Anniversary.

University of London, Slade School of Fine Art, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture V.)

Mechanical Engineers, Institution of, Storey's-gate, Westminster, S.W., 6 p.m. 1. Annual General Meeting. 2. Mr. L. A. Legros, "Traction on Bad Roads or Land." 3. Mr. A. Amos, "Utility of Motor Tractors for Tillage Purposes."

SATURDAY, FEBRUARY 16...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Problems in Atomic Structure." (Lecture I.)

Automobile Engineers, Institution of (Scottish Centre), Technical College, George-street, Glasgow. Mr. D. Drummond, "Coal Oils."

BANKING SUPPLEMENT.

THE LONDON CITY & MIDLAND BANK

ESTABLISHED 1836. LIMITED.

Subscribed Capital, £24,906,432. Paid-up Capital, £5,188,840. Reserve Fund, £4,342,826

DIRECTORS.

Sir EDWARD H. HOLDEN, Bart., *Chairman and Managing Director.*
WILLIAM GRAHAM BRADSHAW, Esq., London, *Deputy-Chairman.*

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WILLIAM FITZTHOMAS WYLEY, Esq., Coventry.

Head Office: 5, THREADNEEDLE STREET, LONDON, E.C. 2.

Joint General Managers: J. M. MADDERS, S. B. MURRAY, F. HYDE, E. W. WOOLLEY.

Dr. LIABILITIES AND ASSETS, 31st December, 1917. Cr.

Dr.	£	s.	d.
To Capital Paid up, viz.: £2 10s. od. per Share on 2,075,536 Shares of £12 each	5,188,840	0	0
,, Reserve Fund	4,342,826	0	0
,, Dividend payable on 1st February, 1918	350,246	14	0
,, Balance of Profit and Loss Account, as below	733,785	5	8
	10,615,697	19	8
,, Current, Deposit, and other Accounts	220,551,768	9	5
,, Acceptances on account of Customers	8,826,865	17	6
	£239,994,332	6	7

Cr.		£	s.	d.
By Cash in hand (including Gold Coin £7,000,000) and Cash at Bank of England		44,110,353	13	10
,, Money at Call and at Short Notice		31,003,560	9	2
,, Investments:				
War Loans, at cost (of which £408,418 10s. is lodged for Public and other Accounts), and other British Government Securities		33,116,534	13	6
Stocks Guaranteed by the British Government, India Stocks, and Indian Railway Debentures		181,789	10	0
British Railway Debenture and Preference Stocks, British Corporation Stocks		1,774,673	4	2
Colonial and Foreign Government Stocks and Bonds ...		660,352	18	0
Sundry Investments		521,463	5	10
,, Bills of Exchange		35,052,991	17	10
		146,421,719	12	4
,, Advances on Current and other Accounts		68,510,358	1	9
,, Advances on War Loans ...		12,645,539	9	0
,, Liabilities of Customers for Acceptances		8,826,865	17	6
,, Bank Premises, at Head Office and Branches		2,837,210	6	0
,, Belfast Bank Shares:—				
49,688 £12 10 0 Old Shares £2 10 0 paid				
148,204 £12 10 0 New Shares £2 10 0 paid				
Cost	£1,225,908 0 0			
Less part Premium on Shares issued	473,269 0 0			
		752,639	0	0
		£239,994,332	6	7

Dr. PROFIT AND LOSS ACCOUNT for the year ending 31st December, 1917. Cr.

Dr.	£	s.	d.
To Interim Dividend at 18 per cent. per annum to June 30th, 1917, less Income Tax	322,703	9	11
,, Dividend payable on 1st February, 1918, at 18 per cent. per annum, less Income Tax	350,246	14	0
,, Reserve Fund for Contingencies ...	500,000	0	0
,, Salaries and Bonus to Staff serving with H.M. Forces and Bonus to other Members of the Staff ...	304,518	19	3
,, Balance carried forward to next Account	733,785	5	8
	£2,211,254	8	10

Cr.	£	s.	d.
By Balance from last Account	243,538	5	10
,, Net profits for the year ending 31st December, 1917, after providing for all Bad and Doubtful Debts	1,967,716	3	0
	£2,211,254	8	10

EDWARD H. HOLDEN, *Chairman and Managing Director.*
W. G. BRADSHAW, *Deputy-Chairman.*
DAVID DAVIES, CARNOCK, } *Directors.*

REPORT OF THE AUDITORS TO THE SHAREHOLDERS OF THE LONDON CITY & MIDLAND BANK, LIMITED.

In accordance with the provisions of Sub-section 2 of Section 113 of the Companies (Consolidation) Act, 1908, we report as follows:—

We have examined the above Balance Sheet in detail with the Books at Head Office and with the certified Returns from the Branches. We have satisfied ourselves as to the correctness of the Cash Balances and the Bills of Exchange and have verified the correctness of the Money at Call and Short Notice. We have also verified the Securities representing the Investments of the Bank, and having obtained all the information and explanations we have required, we are of opinion that such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Company's affairs according to the best of our information and the explanations given to us and as shown by the books of the Company.

London, *14th January*, 1918. WHINNEY, SMITH & WHINNEY, Chartered Accountants, *Auditors.*

THE BANK IS THE PROPRIETOR OF THE BELFAST BANKING COMPANY, LIMITED.

BANKING SUPPLEMENT.

London County & Westminster Bank
LIMITED.

HEAD OFFICE - - 41, LOTHBURY, E.C. 2.
FOREIGN BRANCH - 82, CORNHILL, E.C. 3.

AUTHORIZED CAPITAL - £17,000,000.
SUBSCRIBED CAPITAL £16,552,020, IN 827,601 SHARES OF £20 EACH.
PAID-UP CAPITAL - £4,138,005 | RESERVE - £4,725,948 12s. 6d.

WALTER LEAF, Esq., *Chairman.*
Sir MONTAGU TURNER, *Deputy-Chairman.*

Joint General Managers:
F. J. BARTHORPE, J. W. BUCKHURST.

Secretary:
A. A. KEMPE.

BALANCE SHEET, 31st DECEMBER, 1917.

LIABILITIES.

		£	s.	d.
CAPITAL—				
Authorized	£17,000,000			
Subscribed	£16,552,020			
827,601 Shares of £20 each, £5 paid		4,138,005	0	0
2,177 " " " issuable against outstanding fractions		10,885	0	0
RESERVE		4,725,948	12	6
CURRENT AND DEPOSIT ACCOUNTS ...		142,267,948	17	7
CIRCULAR NOTES, LETTERS OF CREDIT, AND OTHER ACCOUNTS, including provision for Contingencies		4,394,674	16	8
ACCEPTANCES FOR CUSTOMERS		5,375,651	17	5
ENDORSEMENTS ON BILLS NEGOTIATED...		72,956	0	0
REBATE ON BILLS not due		193,215	0	1
PROFIT AND LOSS.				
Net Profit for the year, including £182,291 3 0 brought from year 1916, £1,453,358 5 7. From this the following appropriations have been made:—				
Interim Dividend of 9 per cent. paid in August last ...	£315,000 0 0			
Contingency Fund (Investments and Foreign Accounts)	460,500 0 0			
Bank Premises Account	100,000 0 0			
	£875,500 0 0			
Leaving for payment of a further Dividend of 10 per cent. on 1st February next		393,259	6	8
And a Balance to carry forward		184,598	18	11
		£161,757,143	9	10

ASSETS.

	£	s.	d.
CASH—			
In hand and at Bank of England... ...	25,197,729	14	11
Money at Call and Short Notice... ...	26,983,535	2	1
	52,181,264	17	0
BILLS DISCOUNTED	24,288,393	13	2
INVESTMENTS—			
Consols and 5 per cent. War Loan (of which £950,376 is lodged for Public Accounts), and other Securities of, or guaranteed by, the British Government	32,408,994	16	11
Indian Government Stock, and Indian Government Guaranteed Railway Stocks and Debentures	443,170	14	8
Colonial Government Securities, British Corporation Stocks, and British Railway Debenture Stocks	670,641	16	6
Other Investments	1,465,137	12	5
LONDON COUNTY AND WESTMINSTER BANK (Paris) LIMITED— 8,000 £20 Shares fully paid ... 32,000 £20 Shares, £7 10s. paid ...	400,000	0	0
ULSTER BANK, LIMITED— 194,666 £15 Shares, £2 10s. paid ...	1,861,493	12	6
ADVANCES TO CUSTOMERS AND OTHER ACCOUNTS (including pre-moratorium Stock Exchange Loans)	40,800,158	16	11
LIABILITY OF CUSTOMERS FOR ACCEPTANCES, as per contra	5,375,651	17	5
BILLS NEGOTIATED, as per contra ...	72,956	0	0
BANK AND OTHER PREMISES (at cost, *less* amounts written off)	1,789,279	12	4
	£161,757,143	9	10

WALTER LEAF,
M. C. TURNER,
G. SEYMOUR GRENFELL, } *Directors.*

F. J. BARTHORPE,
J. W. BUCKHURST, } *Joint General Managers.*
A. G. PIKE, *Chief Accountant.*

AUDITORS' REPORT.

We have examined the above Balance Sheet and compared it with the Books at Lothbury and Lombard Street, and the Certified Returns received from the Branches.

We have verified the Cash in hand at Lothbury and Lombard Street and at the Bank of England and the Bills Discounted, and examined the Securities held against Money at Call and Short Notice, and those representing the Investments of the Bank.

We have obtained all the information and explanations we have required, and in our opinion the Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Company's affairs according to the best of our information and the explanations given to us, and as shown by the Books of the Company.

FRED. JOHN YOUNG, F.C.A.,
G. E. SENDELL, F.C.A., } *Auditors.*

LONDON, 15th *January*, 1918.

London: Printed by WILLIAM CLOWES & SONS, LTD., Duke Street, Stamford Street, S.E., and published for the Royal Society of Arts by G. BELL & SONS, LTD., York House, Portugal Street, W.C., in the Parish of St. Clement Danes, in the City of Westminster.—February 8, 1918.

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JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

Published every Friday. *Price to Non-Fellows, 6d.*

LONDON:
Published for the Society by G. BELL & SONS, Ltd., York House, Portugal St., W.C.

REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,404. VOL. LXVI.

FRIDAY, FEBRUARY 15, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 18th, at 4.30 p.m. (Cantor Lecture.) EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." (Lecture I.)

WEDNESDAY, FEBRUARY 20th, at 4.30 p.m. (Ordinary Meeting.) MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." JOHN SLATER, F.R.I.B.A., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

TENTH ORDINARY MEETING.

Wednesday afternoon, February 13th; Mr. R. TOOTILL, M.P., in the chair. A paper on "The Relations between Capital and Labour" was read by LORD LEVERHULME.

The paper and discussion will be published in the *Journal* of March 1st.

INDIAN SECTION.

Thursday afternoon, February 14th; SIR CHARLES S. BAYLEY, G.C.I.E., K.C.S.I., in the chair. A paper on "The Indian Hide and Leather Trade" was read by SIR HENRY LEDGARD, late President, Upper India Chamber of Commerce, and Member, Board of Industries, United Provinces.

The paper and discussion will be published in the *Journal* of March 8th.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers will be supplied, post free, for 2*s.* each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Tuesday, February 5th, 1918; The RIGHT HON. VISCOUNT GLADSTONE, G.C.B., G.C.M.G., G.B.E., in the chair.

The paper read was—

THE INDUSTRIAL RESOURCES OF THE UNION OF SOUTH AFRICA.

By C. DU PLESSIS CHIAPPINI,
Trades Commissioner for the Union of South Africa.

In dealing with the industries of the Union of South Africa in a short paper like this the difficulty at once presents itself of how to find room to make even a brief reference to the numerous trades and industries of the Union, old and new, great and small. The new and minor industries will, perhaps, constitute the most interesting subject-matter, and cannot therefore be excluded; but a review of the industries of South Africa would be incomplete without a reference to the problems of the present, and the great questions of the future, which will considerably influence the course of the development of agriculture, commerce, and industry within the Union.

The Union of South Africa embraces an area of 473,000 square miles, or nearly four times the size of the United Kingdom, and more than twice the size of Germany. It includes the former Colonies of the Cape, Transvaal, Orange Free State, and Natal.

The estimated population of the Union in 1914 was made up as follows:—

Persons of European descent . .	1,368,959
Natives and other coloured people	5,046,585
	6,415,544

Of the coloured people, about one million are already in a fairly advanced state of education and civilisation.

The country is governed by a constitution granted by the Imperial Parliament under the South Africa Act of 1909, in virtue of which each of the four Colonies became a Province of the Union. The legislatures consist of a Senate, a Legislative Assembly for the Union, and a Provincial Council for each Province.

The constitution of the Union affords freedom and protection to all, and security of property to landed owners and investors of funds.

The principal industries of the Union may be divided into three groups—namely, agriculture, mining, and manufacturing. I place agriculture first because to the people of South Africa it is by far the most important, and touches their interests in almost every direction; indeed this war has shown that there comes a time when the destiny of nations is consummated in the one word—"agriculture." Mining ranks next in importance, but it is clear that, when at some remote epoch the rich gold mines are worked out, agriculture and manufactures will be conspicuous as the two chief classes of industry in the Union. It must, however, be frankly acknowledged that the mining industry is the best customer to the agriculturist and the manufacturer, for not only has it done much to promote the development of agriculture, but the great progress made by the manufacturing industries is almost entirely due to the generous support of the mining industry; moreover, it cannot be denied that mining contributes the largest proportion to the State revenue, and that it is the industry which brought about most of the extensive railway developments in the Union.

In reviewing the position of these three groups of industries, one cannot help emphasising the fact that in all of them, especially agriculture and manufactures, great progress has been made during recent years.

The financial position of commerce and industry within the Union is sound, thanks to the wise and careful policy adopted by the leading banking institutions in the country.

Apart from gold and diamonds, the principal products of the Union are raw materials, which are required by the manufacturers in oversea countries, and foodstuffs. It is generally agreed that these important lines of produce will be in urgent demand after the war. The question as to what methods should be adopted to divert the raw materials and foodstuffs produced within the Dominions to the Home Country has been much discussed by leading statesmen, economists, and trade experts; and undoubtedly this is now a matter for serious consideration by the producers in the Dominions who desire to increase their production, and would like to see their goods sold and used within the Empire—a view conceivably shared by the manufacturers in the Mother Country, who, being equally concerned in turning the situation to good account, are anxious to re-establish their factories and again compete in the world's markets with their products. As this question of marketing is of paramount importance, both to the producer of raw materials and to the manufacturer, I cannot avoid referring to it in this paper, though I am loath to do so having regard to the fact that it is a very contentious matter. I am anxious not to side with one side or the other, and should any deduction be made from the comments I make in this paper, it must be clearly understood that these are only my private views. I have no knowledge of the views of the Government or the people of the Union of South Africa upon these questions; and, further, I have in mind only the raw products of the Dominions. My views upon the marketing of imported manufactured goods into the Dominions may be quite different. Each of these classes of trade creates different problems, and must be dealt with on its merits.

The position, as it appears to me, is that the British manufacturers, realising that there is going to be a great shortage of raw materials, and fearing keen competition from undesirable foreign quarters after the war, are considering ways and means of diverting these goods to the home markets. Various proposals have been put forward, but most of them have been demolished at the hands of public critics. To keep the raw materials within the Empire is the objective which all have in view—the producer as well as the manufacturer—and it will, I think, be ultimately achieved by adopting the straightforward policy of the "open road of commerce"—that is to say, the "line of least resistance," and by gravitation rather than by force or other means.

But whatever means may ultimately be decided upon for diverting the Empire's raw products to the Empire's markets, I sincerely trust that they will be of such a nature as will facilitate their transportation to the markets where they are most needed, and consequently will realise the best prices; this is a sure means of increasing the production of these much-needed products within the Empire. If the producers of raw materials see that their hard-won products are, for some reason over which

they have no control, realising lower prices than what similar goods are being sold at in other markets, their discontentment will grow as time goes on, and when patriotism gives way to materialism it is certain that means will be found to place their goods on the markets which offer the best prices.

If, therefore, the roads to all markets are left open, and at the same time special facilities provided by means of subsidies, or other form of State aid, for the transportation of raw materials or manufactured goods to the most-favoured markets, then neither the producer nor the manufacturer will have a valid reason to be discontented.

With the hope that I shall not be considered too critical, I would like to draw attention to the matter of the sale of our raw products in the United Kingdom and foreign countries previous to the war; and I trust that the British manufacturers will carefully consider the question, and thus place themselves in a position to use more of the raw products of the Dominions in the future than they have done in the past.

Before the war, Germany bought annually about 65 per cent. of the South African wool clip, the reason being that they had established plants known as "carbonising machinery" to deal with the vegetable matter in the wool; whereas the British manufacturer was inadequately equipped with this class of machinery, and could therefore not find use for our "burry" wool.

France, on the other hand, bought almost all the "short" wools produced in the Union, because the French manufacturers possessed improved "combing plants," which could best manipulate these short wools.

Then, again, Germany bought by far the greater portion of the South African hides, so I am told, because they are too light for the English market, and the same objection applies to Indian hides, almost all of which were also bought by the Germans.

Germany bought annually about 80 per cent. of the Natal wattle-bark, and notwithstanding that every effort had been made by the exporters and the Union Government to establish markets here, the British tanners, previous to the war, though acknowledging the good qualities of the bark, persistently refused to use it, alleging as their reason that they preferred their tannin material in the form of extract. These raw materials, to which I have referred, were not necessarily shipped direct to Germany, inasmuch as the bulk of them were actually bought at the London sales and reshipped to Germany.

If producers in South Africa are asked to make any special effort to direct their products to the home markets in the future, they will want some assurance that better means have been devised by British manufacturers to deal with the goods—or, in other words, that the products can be used here and are wanted.

Immediately previous to the war the South African producers and shippers were well provided with excellent lines of steamers and had little to complain of, but the question of providing shipping after the war to meet the greatly increased production of raw materials and food products—and especially adequate cold storage accommodation—is a matter for very grave consideration, and as such it is receiving the attention of the Governments concerned. It is in this respect that assistance and co-operation from this country may be opportune. My advice to those who are considering the much-discussed question of "trade after the war" is—See to your shipping; it is the man who sends the ship who will get the goods, and the need for shipping will be such that the question of the "flag" will not stand in the way of the goods which must be shipped. Therefore, if we want "trade with and in the Empire," we must help each other to provide British ships for the Empire's sea routes, and we must do that soon.

AGRICULTURE.

Agricultural and pastoral pursuits have made considerable progress during the six years previous to the war, as the following figures of the values of agricultural and pastoral products exported from the Union during the years mentioned will show: 1907, £7,363,000; 1913, £12,239,000. Unfortunately the figures for 1917 are not yet available; if I were able to give them it would be seen that even under war conditions great progress has been made.

The Union Government possesses a most efficient and well-administered Agricultural Department, composed of several "divisions," the chief of which are agricultural education, sheep, veterinary research, horticulture, viticulture, tobacco and cotton, dairying, botany, chemistry, and entomology. Besides these, there are other important institutions relating to agriculture but independent of the Agricultural Department—namely, the Departments of Forestry, Irrigation, and the Land Bank.

The development in agriculture is largely due

to the attention given to the important question of irrigation, great success having been achieved in this direction, particularly in regard to the diversion of storm-water from the intermittent rivers during the short periods in which they flow; thus the water which used to rush from the inland plateaux to the sea is now utilised and serves to irrigate large tracts of rich loamy soil in the dry arid regions, which are thus made to produce one of the most valuable agricultural products, namely, lucerne, which stock-farmers prize more than any other field product in the Union.

Farming in South Africa has many advantages; and because of the beautiful climate, the healthy outdoor exercise, besides the opportunities for investment and profit which it affords, it has attracted the leading men in the country. It is the ultimate goal of judges, lawyers, other professional men, and merchants. It is the source of much pleasure to the wealthy; it is the boast of the politician; while it always remains the serious means of earning a living and sometimes of making a fortune to the many thousands of hardworking, diligent farmers.

The agriculturist in South Africa is prosperous and thrifty; as a rule he owns the land he works on; he holds a good social position; every opportunity is given him for the education of his children, of which he takes full advantage; he gives great attention to his calling, and is regarded as being progressive, except by those who know nothing about farming.

A great future is assured for the agricultural industry of South Africa, not only the part comprising the Union, but also the adjoining British and foreign possessions.

Wool.

The principal agricultural product is wool. The total value exported during 1907 was £3,128,927; in 1917, £8,782,280. The quantities exported were, in 1907, 97,711,000 lb., and in 1917, 117,657,000 lb. There are 34,000,000 sheep in the Union, of which approximately 9,000,000 are not wool-bearing, but are produced chiefly for their excellent mutton, and because they can resist droughts well and mature quickly. The wool-bearing sheep are chiefly merinos, the breed of which has greatly improved during recent years. The grading and the skirting of the wool for export has also shown remarkable improvement.

Mohair.

This is also an important industry. The Angora goats were originally imported from Asia Minor under special licence from the Turkish Government, and great care was taken in the selection and breeding of the animals, with the result that a very fine quality hair is produced from these thoroughbreds.

The average export in normal times amounts to about 20,000,000 lb., valued at close upon £900,000 per annum. As mohair materials are not essential for Army purposes, the quantity of mohair imported into the United Kingdom during the period of hostilities has diminished; but in normal times South Africa supplies the English market with about 60 per cent. of its total requirements, whilst Turkey supplied the balance.

Hides.

The output of hides in the Union has considerably increased. During 1907 the total quantity of hides exported was 7,456,000 lb., valued at £203,000, and in 1917 the total quantity exported was, approximately, 18,000,000 lb. weight, valued at about £837,000.

Skins.

Sheep and goat skins from South Africa are much prized by glove-makers and manufacturers of leather goods. In 1907 the exports were 24,418,000 lb., valued at £743,000, and the average annual exports since 1913 were about 42,000,000 lb., valued at £1,600,000.

Maize.

Maize has been produced in South Africa since the time of the earliest white settlers, but a serious export trade was not initiated until about the year 1908. During the two preceding years experimental shipments were made under the auspices of the Union Government, and it was then found that the maize, although sound and dry, was "mixed" and not of the type required on these markets. These faults were, however, quickly remedied when they were pointed out to the Government and the producers. New types of maize were introduced, and large quantities of improved seeds were produced on the Government experimental farms and distributed to the growers, with the result that South Africa now exports the finest quality maize to these markets, and the maize is further appreciated because of its dryness in comparison with maize from other countries.

Greater confidence was also established in these markets by the system of Government grading inaugurated, which has been strictly carried out to the satisfaction of the shippers and importers, thus considerably enhancing the success of the maize export trade.

In 1908 the exports amounted to 463,000 bags (200 lb. each), which was increased to approximately 2,200,000 bags in 1917, valued at the ports in South Africa at about £1,540,000.

Ostrich Feathers.

The production of ostrich feathers in South Africa was one of the most successful of the agricultural pursuits in the Union previous to the war. It is an industry peculiar to South Africa, and owes its success to the great care given by the breeders in producing the types of feathers most desired by the markets of the world. Within a comparatively short period the quality and desired shape of the feathers had been vastly improved by the method of breeding by selection, in recognition of the fact that the prime feathers of the domesticated ostrich are of much greater value than those yielded by the bird in its wild state.

South Africa had what was practically a monopoly of the world's markets, having produced about 85 per cent. of the total requirements of the feather trade.

Immediately previous to the war the fashion in ostrich feathers greatly declined, and the trade is now at very low ebb; but as ostrich feathers have been fashionable more or less for forty years, and previously were in use for decorative purposes for nearly 2,000 years, there can be little doubt that when more normal conditions prevail the ostrich feather will again come into vogue, thus restoring the industry to its former state of prosperity. The largest output of feathers was during the year 1913, when 1,023,000 lb. were exported, valued at nearly £3,000,000.

Fruit.

Most of the well-known varieties of tropical and sub-tropical fruits have been cultivated in South Africa since the advent of the first white settlers, but it has only been within the last fifteen years that fresh fruit has been extensively produced with a view to exportation.

The principal varieties of fruit exported are grapes, pears, plums, peaches, apricots, and nectarines. These varieties are grown within one hundred miles of Cape Town.

Great progress has also been made in the cultivation of oranges for export. Many hundreds of thousands of trees of the most suitable and best varieties have been planted. Oranges are produced in many parts of the Union, particularly the Transvaal and the Cape Province. Substantial profits have already been made by orange-growers. I consider that this line of fruit-growing offers great possibilities for the future.

Pineapples, which should also become a big commercial line of fruit, are principally grown in the districts of Albany and East London in the Cape Province, also in the Natal Province. It is anticipated that a large and profitable export trade will be established in this fruit when more normal conditions prevail.

The Union Government has given particular attention to the fruit export trade. Official graders have been appointed at the ports to grade and inspect the fruit before shipment, and qualified packers are sent to all the fruit-growing districts when needed, to instruct the growers in the most up-to-date methods of packing fruit for export, with the result that fruit-growers in South Africa have attained great proficiency in the art, and they now have little to learn in that respect.

The fruit export trade arrived at its highest point immediately prior to the war. Since then the export of fresh fruit has practically ceased, owing to the lack of cold-storage accommodation in the steamers.

During the year 1914, 526,000 boxes of fruit (deciduous and citrus) were exported to this country. It is confidently expected that when more normal conditions prevail, and sufficient cold-storage space is provided in the steamers, the export of deciduous fruit will exceed 1,000,000 boxes per annum, and that the export of oranges will be about equal to that amount.

There can be no doubt that South Africa's fruit export trade will, in time, become one of the country's chief industries.

Dried Fruit.

Dried fruit is another export trade which has a splendid future, and rapid strides have been made in improving the quality and packing of fruit for these markets. An export trade, although at present a small one, has already been started in raisins, prunes, and apricots. For several years past small experimental shipments have been made to the United Kingdom, and the opinions and criticisms of the dealers were carefully noted and reported to the producers, who readily adapted their produce to the requirements of these markets. Developments followed, and during the past year approximately 380 tons of dried fruit, chiefly raisins and prunes, were exported from South Africa to the United Kingdom.

Wattle-bark.

The production of wattle-bark is one of the chief agricultural industries in the Natal Province. This bark, which is a splendid tanning agent, and is stripped from the black wattle tree (*Acacia mollissima*) indigenous to South-eastern Australia, was introduced into Natal about thirty years ago, and since its introduction an industry of first importance has been established.

The cultivation of wattle trees has proved very remunerative to the Natal farmer. The trees are ready for felling and the bark is stripped off when they are about six years of age. The grower usually cuts his trees in rotation, taking six or seven years to go through his plantation, when he commences again *ab initio*. The trees are self-sown, and, with a little care, again come to maturity in the usual time.

At present there are about 160,000 acres of land devoted to wattle-growing, and the annual yield is approximately 65,000 tons of bark, which output is expected to increase considerably. The average price realised for dried bark, bagged and chopped, is from £5 to £6 per ton at Durban. The export of bark in 1907 amounted to 54,500,000 lb., valued at £139,400, and during 1917, 93,532,000 lb., valued at £225,722.

Wattle-bark contains from 28 to 30 per cent. of tannin acid. One of the most valuable by-products is the timber, which is in great demand at the mines for pit props, the sale of which, in some instances, more than recompenses the growers for the cost of producing the bark.

Prior to the war very little wattle-bark was used by the English tanners, and practically the only market was in Hamburg; but since the outbreak of hostilities the bark has been used in England with considerable success.

Shortly after the war broke out, some enterprising persons established factories in Natal for the manufacture of wattle-extract; two factories are now producing the extract, and the new industry has proved to be very remunerative. The extract is of high tanning value and realises good prices on these markets.

It is anticipated that the bulk of the bark produced in Natal will, after the war, be consumed by the local extract factories, and that more of these will be erected.

Frozen Meat.

It is anticipated that the export of meat from the Union will become one of the most important industries of the future. The war has undoubtedly given a great impetus to this trade, but it must be remembered that the matter was much discussed in the Union and seriously taken in hand by the Government previous to the war, because it was then seen that, while the meat supplies of the world were gradually diminishing, the number of cattle and sheep in the Union was increasing. At one time it was feared that the ravages of the East Coast fever would seriously hamper the development of cattle-farming; but, thanks to the energies of the Director of Veterinary Research, and to the system of compulsory dipping, the East Coast fever is being checked, and the number of cattle in the Union is multiplying rapidly. Southern Rhodesia opportunely came forward with large contributions of cattle, which, I frankly admit, considerably helped to swell the supplies shipped from Union ports during the past year. It is generally acknowledged that cattle-ranching in Rhodesia has a great future.

The class and breed of cattle have been immensely improved during recent years, and I consider that this is largely to be attributed to the generosity and public-spiritedness of the Union Castle Steamship Co., for having undertaken to carry pedigree stock free of charge from Europe to the Union. Great use has been made of this concession, and since it came into operation many hundreds of valuable pedigree animals have been shipped to South Africa.

The total number of cattle in the Union is estimated at 8,000,000, and, as previously stated, the total number of sheep is 34,000,000.

It is interesting to note that New Zealand, with a consuming public numerically slightly below that of South Africa, and with only 24,000,000 sheep, is the biggest exporter in the world of mutton and lamb.

South Africa has, however, now determinedly entered into the market with the exportation of beef. In this connection it may be pointed out that only five years ago South Africa was still importing meat, whereas the total exports of beef from the Union during 1917 exceeded 21,000 tons, valued at £1,160,000 at the ports of shipment.

Great attention has recently been given to the establishment of modern abattoirs and packing-houses, and while it has not been possible for the promoters of these schemes to obtain the machinery during the war, preparations are being made for setting up plants immediately hostilities cease, much experience having been gained during the war which will be useful in

the future. Plans are also being matured for the erection of meat-canning factories, which are a necessary adjunct to a meat export trade; moreover, there is always a considerable market in South Africa for canned meat.

Butter.

This is another agricultural industry which has made rapid progress during recent years; the success which has been achieved is largely due to the untiring efforts of the dairying division of agriculture, which has encouraged the formation of dairies and creameries in the pastoral districts of the various Provinces. At present there are fifty-two creameries in the Union.

The annual production of butter by established dairy factories in the Union is about 14,000,000 lb. The export of butter to the United Kingdom for 1917 was about 54,200 cases.

Eggs.

The export of eggs is also a new undertaking to which the Government has given great attention. Government graders have been appointed at the ports, and the best known systems of packing and grading have been adopted, with the result that the eggs are arriving on these markets in excellent condition.

To illustrate the growth of this new trade, I submit the following export figures: During 1914, 2,300 cases; in 1916, 24,000 cases. (A case contains thirty dozen eggs.)

The question of the export of liquid eggs is also receiving the attention of the shippers, and quite recently an experimental consignment was made of liquid ostrich eggs, which was favourably reported upon by trade experts.

Cotton.

For the past ten years the Union Government has given much assistance to farmers in order to encourage the production of cotton in the Union, with the result that the industry has made satisfactory progress. The cotton produced is of good quality, and meets with a ready sale on these markets.

According to the latest figures there are approximately 5,200 acres under cultivation in the following districts:—

Rustenburg	3,000 acres.
Waterberg	2,000 ,,
Zoutpansberg	100 ,,
Natal	100 ,,

In addition to these there are one or two small cotton areas in the Middelburg district, the Orange Free State, and the Cape Province. The annual yield for the season 1916–17 was 700,000 lb. seed cotton and 233,000 lb. of lint.

Throughout the Union there are considerable areas where the soil and climatic conditions are suited for cotton cultivation.

The question of dealing with the by-products of the cotton is receiving serious attention; two small plants have already been erected to crush the seeds for oil and oil-cake.

Fishing.

The fishing industry of South Africa is a very important one. The seas round the coasts of the Union abound with many varieties of good quality fish. The types vary to some extent in the waters of the different parts of the coast.

Formerly the industry was in the hands of the Malays and coloured people, Cape Town being the principal centre; but subsequently Italian fishermen established themselves and almost monopolised the industry at some of the ports.

Later on, however, steam trawlers, of which there are now nine, were introduced by one of the large English fishing companies, and their operations have proved to be most profitable.

As the result of facilities offered by the railways, fresh fish in large quantities is carried far inland to every part of the Union by means of refrigerator cars, and it is a pleasant surprise to the traveller, a thousand miles inland, to be served with fresh deep-sea fish in the railway dining saloons, and in the hotels even of the small country villages.

The big inland towns like Johannesburg, Kimberley, and Pretoria have become profitable markets for the fishing industry.

A most important section of the fishing industry is the canning of crayfish or "spiney lobster." There are seven factories engaged in this industry, and they are situated in the neighbourhood of Cape Town and at Saldahana Bay. The quantity exported to the United Kingdom during the past year was, approximately, 1,750,000 lb., valued at £150,000.

A considerable quantity is also consumed locally. The industry, as a whole, has proved to be a most profitable one.

Whaling is also an important section of the fishing industry, and several companies and firms have established whaling stations at different points along the coasts of the Union. The exports of whale oil during the year 1916 amounted to 901,796 gallons, valued at £60.295.

The fishing industry generally is controlled by Boards of Fisheries under the direction of the Minister of Industry, who is advised by competent biologists. In recent years regulations have been framed, defining the seasons and

restricting the areas, as well as the size of the different types of fish which are permitted to be caught on the various fishing-grounds.

MINING.

In point of value mining is the most important industry in the Union at present. The gold and diamond mines of the Union are world-famous, and contribute by far the largest amount to the total output of minerals; but coal-mining, which has rapidly developed in recent years, is of the greatest material value to the country. The total value of the mineral output of the Union in 1916 was £50,593,000.

There are nearly 316,000 persons employed in the mines of the Union. This does not, of course, include the large outside population residing in mining towns and along the reefs, who are living indirectly on this prosperous industry. Of the number of employees in the mines, about 32,000 are whites and about 284,000 natives.

The annual value of stores consumed on the mines is approximately £14,000,000 per annum, of which more than half consists of agricultural products and goods manufactured within the Union.

The total production of gold in South Africa since 1868 up to date amounts approximately to £545,000,000 in value. South Africa contributes annually about 41 per cent. to the world's output of gold.

Though gold was being mined at Barberton, Pilgrim's Rest, and other parts of the Transvaal for many years previously, it was only in 1886 that the Gold Reef was discovered, which has alone contributed more to the world's output than any other gold-producing country in the world—I refer to the Main Reef of Witwatersrand. It is most remarkable that in comparison with the gold reefs of Australia, New Zealand, India, and the United States of America, it is the lowest in yield per ton; but owing to the consistency of the sedimentary deposits and the extraordinarily even distribution of the gold, it forms a payable mining proposition and a safe and profitable investment for capital.

The present gold production is at the rate of about £40,000,000 per annum, practically all of which is produced in the Transvaal. The average yield of ore mined in 1916 was 26*s.* 4*d.* per ton. The value of the yield is gradually decreasing; in 1910 it was 28*s.* 9*d.* per ton.

The total capital invested in the gold mines of the Union, practically all of which are in the Transvaal, is £82,373,000. The net profits of the mines amount to about £9,000,000 per annum, while the annual dividends on the share and debenture capital amount to about £8,000,000 per annum.

Diamonds.

Diamonds are the next most important mineral product of the Union; the mining of which in the past brought great prosperity to the Cape Colony during a period when it was most needed.

The first diamond was accidentally found in the district of Hopetown, in the Cape Colony, in 1867. In 1870 more diamonds were discovered on the banks of the Vaal River. Rapid progress was then made in the discovery of diamonds, not only along the great rivers—which are still known as "river diggings," and which still yield a fair proportion of the valuable stones—but deposits were subsequently discovered on the borders of the Orange Free State, which was then a portion of practically free native territory occupied by Griqua tribes. It was here that the De Beers, Bultfontein, and Kimberley mines and other valuable deposits were found in close proximity to each other.

These mines are now all worked by the De Beers Diamond Mining Company, which is the greatest concern of its kind in existence.

Mines were also discovered in the Orange Free State, some of which have proved to be very profitable.

In 1902 the Premier Diamond Mine was discovered in the Transvaal and rapidly developed; it has since become the second greatest producer of diamonds in the world, whilst the largest stone in the world, known as the "Cullinan Diamond," which weighed 3,025 carats, or nearly 1½ lb., was found in the mine.

The output of diamonds is sold in virtue of an agreement between the producing mines and a syndicate, for the purpose of regulating and controlling the prices. It has also been found necessary by the mines to regulate their output according to the demand.

The largest annual output was in 1913, when 5,503,000 carats were produced, and the value of diamonds exported amounted to £12,016,525.

According to available records the value of the diamond output to date since the earliest records have been kept, is approximately £178,000,000.

From the latest figures the number of persons employed in the diamond industry are 2,627 whites and 17,563 natives; whilst the alluvial diggings employ 2,899 whites and 13,666 natives.

Coal.

From a commercial and industrial point of view coal-mining is the most important of the mineral industries in the Union. It is of comparatively recent development, inasmuch as, not many years ago, South Africa imported coal for the working of machinery and for the bunkering of ships calling at the ports.

It is rather an extraordinary geological coincidence that coal should have been discovered in close proximity to the Main Reef at the time when that important gold-producing area was discovered, and thus materially helped in the development of that great industry.

The coal-mines of the Union are situated throughout the four Provinces, the Transvaal being the largest producer. The mines in that Province are situated in the district of Middelburg, also east of the Witwatersrand and in the Ermelo and Zoutpansberg districts.

The coal-fields in Natal are the next in importance, the principal coal-producing area in that Province being the Klip River district.

In the Orange Free State the coal-fields are situated chiefly in the north and north-west areas of the Province, and in the Kroonstad district.

The coal-fields of the Cape Province, which are the oldest in the Union, have not developed to any extent.

There are also undeveloped coal-seams in Natal and the Transvaal, and it is agreed that only a very small portion of the coal deposits of the Union have so far been exploited, and that the industry is capable of considerable developments for an indefinite period.

The bunkering of coal has become an important factor in the industry, and the South African ports have, as a result, become ports of call for many steamers passing along the highways of the Southern Seas.

The following figures will show the quantities and value of coal produced and sold within the Union during 1916:—

Province.	Tons (2,000 lb.).	Value. £	Per ton. s.	d.
Transvaal . . .	6,136,913	1,382,680	4	6·07
Cape	41,752	24,092	11	6·49
Orange Free State	762,576	198,699	5	2·54
Natal	3,066,261	1,134,194	7	4·77
	10,007,502	2,739,665		

The figures given below show the quantities of coal exported from and bunkered at South African ports and produced from mines within the Union during 1916:—

Province.	Tons of Coal Bunkered.	Tons of Coal Exported.
Cape Town	559,331	7,453
Port Elizabeth . .	124	—
East London . . .	98	—
Durban	1,224,091	159,016
Delagoa Bay . . .	379,313	399,167
Knysna	1,305	—
	2,164,262	565,636

Much attention has recently been given to the possibilities of the production of the by-products of coal, which promises to open up new fields of industry within the Union.

Copper.

The mining of copper is one of the oldest mining industries in the Union. It was at first carried out entirely in Namaqualand, a portion of the Cape Province. Subsequently discoveries were made in the Zoutpansberg district in the Transvaal, and in other parts of that Province.

Since the earliest date of existing records, the total quantity of copper produced within the Union is valued at over £22,000,000 sterling.

The following figures show the output of the Union during 1915:—

Province.	Tons (2,000 lb.).	Value. £
Transvaal (per cent. of pure metal, 43·38). .	14,996	525,106
Cape (per cent. of pure metal, 44·48) . . .	13,973	517,208
	28,969	1,042,314

Cement.

The manufacture of cement has become a very important industry in the Union, and is of particular commercial benefit to the country, especially now that shipping space is so limited.

Quite recently nearly all the cement used in the Union came from overseas, but now practically no cement is imported. An excellent quality of cement is manufactured in the

Union, the largest factory being the Pretoria Portland Cement Company, which alone produces nearly half a million casks of cement per annum. The raw material is drawn almost entirely from the district of Pretoria. About 200 tons of gypsum, which is supplied by farmers in that district, is annually consumed by this factory.

Another important cement works is the Whites South African Cement Company on the Vaal River.

The cement supplied by these companies is now accepted by Government contractors for the construction of huge concrete railway bridges, harbour works, and many other substantial structures, and has to conform strictly to specification and tests.

Many other minerals are also produced in the Union. Some of these are developing into important industries.

The following figures show the values of the minerals produced during 1916, to which I have not previously referred to in this paper:—

	£
Tin	339,571
Silver	106,311
Asbestos	83,070
Graphite	1,780
Magnesite	1,766
Antimony	15,292
Zinc	5,202
Corundum	7,762
Mica	1,185
Iron Pyrite	8,019

MANUFACTURING INDUSTRIES.

South Africa, like all other countries, possessed industries from the earliest times. These industries were, however, more or less of a domestic nature—*e.g.* small corn-mills, harness factories, cart and waggon factories, tanneries, etc., and catered only for some of the wants of the localities in which they were situated.

For a long time the mining industry attracted all the attention of the capitalists and the enterprising, while the more settled section of the communities devoted their attention to the development of agriculture, which also offered a profitable outlet for capital, labour, and energy.

But there has been a great awakening; the times and conditions have changed; much capital has been invested, and factories have followed factories throughout the Union; up-to-date plants have been erected everywhere, while experts and scientific men, and managers and foremen of great practical experience have been brought from manufacturing centres in other countries, and many experiments have been made, not without losses, and valuable experience was gained—all of which are necessary when industries are being established in new surroundings. Now, however, in several lines of manufactures considerable success has been achieved, and there is no question that the manufacturing industry has become an important factor in the economic welfare of the Union.

Long before the war, great progress was made in this direction, but since the war a considerable impetus has been given to local industries, insomuch as it was found to be most difficult to import the classes of manufactured goods as in normal times. Necessity being the mother of invention, these very difficulties have been turned to good account, to the lasting benefit of the country.

From the following figures disclosed by the recent Industrial Census, giving the value of the products at the periods mentioned, of the factories in the Provinces and the Union, it will be seen that, after a period of thirteen years, the value of the output of the factories has nearly doubled:—

1904.	£
Cape	9,040,579
Transvaal	6,471,082
Natal	4,076,088
Orange Free State	977,645
Total	£20,565,394

1917.	£
Cape	14,761,000
Transvaal	13,731,000
Natal	9,314,000
Orange Free State	1,885,000
Total	£39,691,000

The amount of capital invested in industries and in factories in the Union and in each Province is returned as follows:—

	£
Cape	14,941,000
Transvaal	17,533,000
Natal	10,657,000
Orange Free State	2,334,000
Total	£45,465,000

The following figures show the number of

persons of different races employed in the factories of the Union:—

White	Male	34,279
,,	Female	4,564
Natives	Male	33,855
,,	Female	383
Asiatic	Male	10,081
,,	Female	1,106
Other coloured	Male	11,839
,,	Female	3,327
Total	Male	90,054
,,	Female	9,380
Grand total		99,434

The returns also show that the wages paid annually to the white persons engaged in factories are £6,633,000, and to all coloured persons, £2,148,000—a total of £8,781,000.

The following tables, showing the number of different classes of factories in the Union in 1917, may be of interest:—

The Government control of matters connected with manufacturing industries is vested in the Minister of Mines and Industries, and is administered by the Industries Section of that Ministry.

An advisory Board, presided over by the Secretary for Mines and Industries, consisting of ten members who have knowledge of the mining, agricultural, industrial, and commercial problems, has been constituted; also a scientific and technical Advisory Committee composed of qualified scientists drawn from the principal scientific institutions and centres of learning in the Union.

Because of the high rates of shipping freights which are likely to prevail for several years after the war, South Africa will, in the near future, offer greater advantages for the investment of capital in industrial enterprises than ever it did in the past.

The enterprising manufacturer or investor who erects a factory in South Africa to utilise the raw materials produced in the Union, will

NUMBER OF FACTORIES.

Classification of Industries.	Cape.	Natal.	Transvaal.	O.F.S.	Union.
Treatment of raw materials, the product of agricultural and pastoral pursuits	65	11	7	1	84
Processes in stone, clay, earthenware, and glass	87	29	83	25	224
Working in wood	91	29	36	9	165
Metals, engineering machinery, and cutlery	157	73	231	31	492
Preparation, treatment, and preserving of foods, drinks, and condiments	712	192	311	115	1330
Production of clothing, textile fabrics, and similar articles	281	53	124	21	479
Books, paper, printing, and engraving	120	44	65	12	241
Vehicles (mechanically propelled and otherwise), fittings for, and parts of vehicles, saddlery, and harness	194	58	88	26	366
Ship and boat building and repairing	4	5	—	—	9
Furniture, bedding, and upholstery	60	19	38	—	117
Drugs, chemicals (including fertilisers and by-products), paints, varnishes, and allied products	31	19	25	—	75
Surgical, dental, and other scientific instruments and apparatus	5	4	5	—	14
Jewellery, timepieces, and plated ware	9	7	9	—	25
Heat, light, and power	42	22	49	14	127
Leatherware (excluding boots and shoes, harness and saddlery)	2	—	—	—	2
Building and contracting	140	35	80	30	285
Other Industries	6	4	2	—	12
Total	2006	604	1153	284	4047

find that a large margin of protection against the imported article will be afforded to him if the cost of freight for the export of the raw materials and the freight on the imported manufactured article is reckoned; besides which South Africa now has an ample supply of coal at reasonable rates, and a plentiful supply of cheap unskilled labour, which has vastly improved in recent years and has become more suited for factory labour.

With regard to markets for the manufactured goods in South Africa, it must be pointed out that as civilisation advances amongst the huge native populations in the Union and the adjoining British and foreign possessions, so the demand for certain classes of manufactured goods will increase; besides which the wants of the rich mining and the extensive agricultural communities are worth catering for.

I will now comment briefly on some of the more important industries of the Union.

Corn-mills.

Amongst the older industries, corn-mills have recently been much improved. Modern machinery has been put up to deal with maize and oats and other South African cereal products. The maize farina, such as semolina, flaked maize, etc., prepared by these mills, is of the highest quality and forms excellent household foods; while, thanks to the dryness of the climate, the oatmeal produced in the Union is of better quality than that produced in other countries where the climatic conditions are not so favourable.

Boot Factories.

There has been considerable development in the boot-manufacturing trade, and several modern factories are now working successfully on quite a large scale.

During the war large Army contracts for the requirements of the South African troops operating in West and East German territories were successfully carried out, and some of the South African boot factories sent samples of their goods to the War Office here with the request that they should be allowed to tender for the requirements of the Imperial forces, subject to compliance with the War Office specification, but their offer was not accepted.

Leather.

The tanning industry of the Union has made rapid progress during the past few years, and a good type of both sole and upper leather is now being produced.

There are at present about twenty tanneries in the Union, and the output of leather for 1917 is valued at approximately £500,000.

The industry is sure to develop substantially in the future, and there will be plenty of opportunities for the investment of additional capital. In this connection it should be borne in mind that the raw materials used in the tanning trade are produced in large quantities within the Union. I refer to hides, sheep, and goat skins. and to Natal wattle-bark and extract, the latter being one of the best tannin agents used by tanners. Besides these advantages we have also cheap labour, reasonable cost of living, and low taxation.

Small shipments of leather from the Union were made to the United Kingdom during the early part of last year. But later the South African tanners were refused permits to ship their leather to these markets.

Explosives.

The manufacture of explosives is an important industry. Besides the Cape Explosive Works, which are conducted on a very large scale in Somerset West at Cape Town, there are also two large factories established by well-known English firms operating in the Transvaal and Natal.

Wine.

One of the oldest industries of South Africa is that of wine-making. The earliest Dutch and Huguenot settlers, as far back as 1688, commenced planting vineyards. During the eighteenth century Cape wines, principally of the types known as "Constantia," were famous on the English market, their introduction being primarily due to the energy of the well-known firm of Messrs. Gilbey, Limited. In 1861, however, in consequence of the equalisation of the import duties on wines entering the United Kingdom, Cape wines failed to maintain their footing on the London market in competition with wines from other countries, and a comparatively large export trade was summarily almost extinguished.

The Western Province is unique in South Africa as a wine-producing region, and it must always remain so, seeing that it is only there that the climatic conditions are found which are required for the successful cultivation of grapes for wine-making. About 90 per cent. of the grapes produced in South Africa are grown in the Western Province, and within 150 miles of Cape Town.

The annual production of wine in the Union

is between four and five million gallons; about half of this is converted into brandy, for which the most modern stills have now been erected. The quality of South African brandy has vastly improved, whilst the production of the older types of brandies, which are not favoured in the wine trade, is now discouraged by the Government, the excise duty on the latter being considerably higher than on the brandy produced with modern stills.

Notwithstanding the many setbacks experienced, the industry is very prosperous. The Government has given every possible assistance to the wine-growers: some years ago well-known experts were engaged from other wine-producing countries of the world in order to instruct farmers how to improve the many types of wines. More recently South African students were sent to wine-producing countries in Europe to acquire proficiency, and they have returned to fill the place of experts in the wine trade. Important results have been achieved, and Cape wines are now of a much higher quality, and, further, they can be produced cheaply.

Had it not been for the shortage of shipping space during the past three years large quantities of wine would have been brought to this market.

Meantime, however, a highly successful commencement has been made by one of our most progressive firms of Colonial wine merchants to re-establish Cape wines on this market, and I sincerely hope that before long the trade will be firmly established.

Sugar.

One of the most important industries closely allied with agriculture is the production of sugar from cane. The output of the Natal sugar industry previous to the war was estimated at about 120,000 tons per annum. The output for 1917 is valued at £3,000,000 sterling.

The area of sugar-cane under cultivation is approximately 61,300 acres, extending along the coast-line of Natal, north-east towards Zululand, and south-west towards the Transkai border.

There are now about thirty-four sugar-mills and one large refinery in the Natal Province.

The labour employed consists chiefly of natives and Asiatics, and the supply is quite plentiful.

The industry is a fairly old-established one, but some years few ago a considerable impetus was given to it by the Government opening up land in Natal and Zululand, and establishing the central mill system.

Each year the area under sugar-cane is increasing, and it is expected that in the near future sufficient sugar will be produced to allow for a surplus to be exported.

Tobacco.

The tobacco industry is widely followed throughout the Union, and large areas of land are now devoted to its cultivation.

There are several Government tobacco experimental stations in the Union under the control of expert tobacco planters. Knowledge gained at these stations is imparted to the tobacco growers in those areas.

There are many commercial types of tobacco produced within the Union. The bulk of the trade consists of the manufacture of rolled tobacco, which is largely used by the farmers and the natives for pipe-smoking, the inferior classes being used for "sheep dip" and disinfectants. A big trade is also carried on in cut tobacco, the centre of which is Rustenburg, from where the famous "Magaliesberg" tobacco comes. This is a pipe tobacco of very high quality, and is much prized by those who are used to smoking it.

Turkish tobacco of very high quality is also produced, the centre of production being in the neighbourhood of Paarl and Stellenbosch, in the Western Province of the Cape, where nearly 500 acres of land are annually planted with this type of tobacco. Samples which were sent to this market were submitted to the greatest experts, who declared that the South African Turkish tobacco is the nearest in quality to tobacco produced in Turkey.

There are large tobacco and cigarette factories in the Union, especially in Cape Town, where huge quantities of cigarettes and tobacco are manufactured and put up under well-known brands, which supply the markets of the Union and the adjoining British and foreign territories. The value of the output of these factories for 1917 is estimated at £1,000,000.

Sundries.

Other trades which also have made much progress are candle and soap factories, which have been erected by well-known old-established English manufacturers. The present annual outputs of these industries are valued at £625,000 and £900,000 respectively.

The number of bacon and ham factories has

increased, and much improved the quality of their products.

Biscuits, cakes, sweets, and confectionery factories, have also been established in different parts of the Union, and even before the war their products could compete in quality and price with the imported articles.

Jam and fruit-canning factories have been successfully established, and fairly large quantities of South African jams have been shipped to these markets during the past year, and about 3,000,000 1-lb. tins were supplied to the War Office. The output of the jam factories in 1917 is estimated at £318,000.

Many other classes of industries are also being developed, and factories are now working and producing such articles as chloride of lime, carbide, iron (smelted from local ores), wattle-extract, glass bottles, alcohol, motor fuel, sulphate of ammonium, asbestos manufactures, tin, white arsenic, starch produced from maize, antimony, canned meat, chicory, and toys.

Railways and Harbours.

A paper dealing with the industries of South Africa would not be complete without a reference to our excellent system of railways, with which are associated the docks and harbours of the Union, because they fall under one administration. The people of South Africa are proud of their railways, not only because they are a great national asset, but also because they are well managed and afford comfort to the traveller and facilities to the producer and the trader.

The railways are the means of opening up and developing large areas of land which formerly produced very little, and are useful as a means of assisting in the establishment of new export trades by carrying the products from the far inland parts to the coast at much reduced rates.

The goods and passenger rates compare favourably with almost any railway in other parts of the world, and the accommodation and attention afforded to passengers for long-distance travelling surpasses in comfort that which is provided by few railways in other countries in comparison with the cost of the fares.

The Union possesses first-class docks and harbours at the different commercial ports which are fitted with all modern appliances, and which will accommodate and cater for the requirements of large steamers up to about 15,000 tons burden. The rates for coal and water are low, and the dock dues are not excessive; in fact, the charges are fixed with a view of attracting steamers to ports of the Union.

Position at end of 1916.

Total open mileage of South African railway lines . . . . (miles)	9,419
Total capital invested in the Government railways	£ 92,063,504
Surplus of earnings over working expenditure (not including interest on capital)	4,365,000
Capital expenditure on harbours . . .	10,200,167
Loss after paying interest on capital .	39,280

Conclusion.

In conclusion, I have to say that, in emphasising the prosperous position of the Union of South Africa, I have in no way overstated the case. It may be said that the enhanced export figures are due to the high prices of the produce. This is correct with regard to some lines, but against this I will point out that there are several classes of products for which no shipping space could be found during the war, and of which large quantities are still awaiting shipment in South Africa, whereas, in other cases, especially in the case of fresh fruit, the export was entirely stopped.

I am convinced that had it not been for the war, the progress of development in agriculture for the past three years would have been greater, and that the total export figures of agricultural produce would have been larger than those already quoted.

DISCUSSION.

The Chairman (Viscount Gladstone) said that he sympathised very heartily with the personal tribute to South Africa with which the author concluded his paper. The longer one lived in South Africa the fonder one became of it; it was a country of increasing fascination, and personally he always took a deep interest in everything that concerned it. The author had rightly said that South Africa was a loyal part of the British Empire. Especially at this time English people liked to remember that that was so; they knew now something of the immense sacrifices and heroisms of South Africa's sons on many a hard-fought field, and they felt it to be their duty to take an interest in all the details of the trade and commerce of South Africa, which were of the highest importance not only to that country but to the Mother Country as well. The author had described the number and variety of the trades and industries of South Africa, and probably many who did not know very much about the country would be surprised to hear how great and varied those trades and industries were. Many of them were as yet small in their development, but still

promised well for the future; others were doing very well at the present time, and not a few had attained quite large dimensions. Most people, when they thought about the industries of South Africa, thought at once of gold. It was true that gold was a very important industry in South Africa, supplying capital and revenue—both very useful things, especially in a new country—but it must be remembered that the production of gold had its disadvantages, in that it absorbed over 300,000 men, and therefore produced a shortage of labour which was essential to other industries. He had no doubt that the gold industry in South Africa would last for many generations, but if in the course of one or two generations it began to decline, he would not look upon that with any apprehension, because the labour would gradually be diverted to other industries which would be to South Africa of even greater value, and would tend to build up its economic future on greater and perhaps safer lines. With regard to exports from South Africa, they were not very large compared with those of older countries, but it must be remembered that South Africa did produce a great many commodities in the shape of raw materials which were greatly needed by this country and which, for some reason or other, other countries had been using a great deal more than we had. English manufacturers and business men must be made to realise the merits of South African goods, so that this country might not have the somewhat humiliating spectacle of raw materials being brought here and then sent off somewhere else to be made up into finished products—and not to a very desirable quarter. The subject of food was of even more importance to this country at the present time than that of raw materials; and, if we had been more alert in past years, South Africa would now be sending us more food than we were at present receiving from her. There was no limit to the possibilities of the development of food exports from South Africa; it was only a question of organisation and of using the vast spaces of the country. The railways, harbours and shipping were all ready, and if the industry was developed South Africa might become a great exporting country of meat, cereals, especially maize and wheat, sugar, and many other food substances. The fact that South Africa was now exporting about 2,000 tons of butter a year was of enormous potential importance to this country. South Africa required capital and labour, and he hoped the people who proposed to conscribe capital would be kind enough to leave a little for the development of South Africa, and that the various schemes put forward would be pared down by criticism and sound advice, so that the economic possibilities of South Africa would not be imperilled. Whatever was done for the promotion of its industries, there was no question of bolstering up those which were unsuitable for the country and costly and uneconomical. Experience had already shown that a great number of excellent industries had been started in South Africa on their own merits and were doing very well; whether or not they needed any further help he was not going to say at the present moment, but, at any rate, he was not afraid of any plans for their encouragement if those plans were clearly limited to vital industries, industries essential to the well-being not only of a particular part of the Empire but of the Empire as a whole. He had personal knowledge of the fact that the industries started in South Africa were started on excellent lines, were essentially economical, and were being built up on the soundest and best scientific principles; and when that condition of things prevailed he was not afraid of the plans of theorists and economists, with some of whom perhaps he did not agree. The author stated at the beginning of his paper that the constitution of the Union of South Africa gave freedom to all. That was quite true, and if one wished to develop the industries of a country one must see that the people of that country had full trust and confidence in the Government under which they had to live. South Africa was a difficult place with regard to politics; there was a good deal of exaggeration about them, and various questions arose very suddenly, and were apt to be forgotten almost as quickly as they arose. It was, however, one of the freest countries in the world, and by no ingenuity could any scheme of government give a freer life to the people who lived in South Africa. There were great onslaughts of political parties in that country, as there were in every country, and the past history of South Africa, perhaps, made people pay more attention to any signs of michief or danger; but for his part he was an optimist, and always had been an optimist, about South Africa, because in all the racket of South African politics no rational being had ever proposed to alter the Union, which gave security and the power of development to all its subjects. The Union of South Africa was a structure built of cement, reinforced by the knowledge that it was to everybody's interest to maintain it, and he believed that the structure which had been set up in the Act of Union would outlive all temporary difficulties that might arise. A hundred years hence it would still be flourishing, and so would its people—in manufactures, in agriculture, in exports, they would be taking a prominent place in the British Empire and in the world. The best return those present could make to the author for having brought the subject of the trade and commerce of South Africa so clearly before them would be to take to heart what he had said, and do all they could to develop that trade and commerce, for the benefit of South Africa and of the whole Empire.

Baron E. B. d'Erlanger said that, although he had never visited South Africa, he had for many years taken an interest in the development of the British Empire and particularly in that of South

Africa. With regard to the soap industry in South Africa, to which the author had referred, he had personally played a considerable part in the building up of that industry in the Transvaal, where it had been very successful. The Company was called the New Transvaal Chemical Company, but he might almost call it the United Trades of South Africa, because the industry was being developed in every possible direction. He was also a Director of the firm of Messrs. Pauling & Co., who had constructed about 40 per cent. of the 9,000 miles of railway that existed in South Africa, and of the British South Africa Company, which administered Rhodesia. He felt sure that sooner or later Rhodesia, as well as those colonies which we had just wrenched from German domination and oppression, would form part of the Union of South Africa. The possibilities of the industry and agriculture of Rhodesia were practically the same as those of the Union of South Africa. A country which was so well endowed with a natural wealth of soil, with gold, coal, iron, copper, asbestos and many other such metals, was one day sure to form the nucleus of one of the greatest industrial countries of the world. The British Empire had been developed and attained its present position on the keystone of commerce, industry and finance, concurrently with its Constitution, which had made its subjects so happy under its rule. If after the war, when its ravages had to be repaired, the British Empire was to continue its progress, the full development of all the resources of the Empire was absolutely necessary. If a capital tax was imposed in this country of such a magnitude as to cripple the financial potentiality of the country in after years, we should not be able to resume the development of the British Empire at the rate that was necessary to repair the ravages of the war, and he hoped the Government would take that fact into consideration.

Sir Charles H. T. Metcalfe, Bt., said that much of the progress of South African industries, to which the author had referred, was of very recent date. He could remember that four years ago eggs were imported into South Africa from Madeira and butter from New Zealand, whereas at the present time South Africa was exporting both of those products. There were also certain really important industries which were only in their infancy, such as the export of citrus oranges and lemons, which would arrive in this country at the time when they were most required—in June and July. He thought there was a very great future before that industry. The cotton industry was also only just beginning; he had been urging its development for very many years, and now it seemed to have really started. There was an enormous field for the development of the cattle trade; he had been through the statistics of farm after farm in Rhodesia, and found that the average increase of cattle, counting accidents, death, and so on, was sevenfold in five years. South Africa was very rich in base metals, which up to the present had not been worked to any extent. It took a long time to establish an industry of that kind, as could be seen by the history of the Tata works in India, and he has been trying since 1888 without success to start the establishment of iron-works in South Africa. He trusted, however, that he would live to see steel and iron works started by some broad-minded person in Africa, because the material was there in abundance, and the labour available was of the best variety.

Sir Edward Penton, K.B.E., in moving a vote of thanks to the author, said the paper showed that Mr. Chiappini possessed the gift of imagination, which Englishmen, sound as they were in commerce, frequently lacked. That imagination would have to be instilled into our trade development if we were to make full use of the produce of the Empire.

Mr. R. C. Hawkin, in seconding the resolution, said the paper was very opportune, for, after the Napoleonic wars, our Parliament voted £50,000 to encourage emigration from this country to South Africa, the reason for that being not so much that South Africa required the population as that the effect of the Napoleonic wars upon industry made some scheme of emigration absolutely essential to Great Britain. The organisation of that scheme was full of interest and importance to this country at the present time. There was no doubt that after the war there would be thousands of men who would be unwilling to return to their former employments, and would desire to emigrate to the Colonies. That was a state of affairs with which the Government of this country would have to deal, and he could not imagine any country more likely to attract those men than South Africa. There was a vast body of good unskilled labour in South Africa that required a certain amount of supervision; there were vast undeveloped resources; and there was a financial position in South Africa far stronger than in any other part of the British Empire. It was uncertain which of the various industries of South Africa would be taken up by the immigrants, but he thought the author was quite right in dealing with agriculture first. The tendency of the population in South Africa was to move from the towns into the country, and that movement would probably continue in increasing volume after the war. The fortunes to be made in agriculture in South Africa made even the gold industry seem unattractive. He saw no reason why the great coal resources in that country should not be developed. Coal was the main cause of England becoming a successful industrial country, and few people had any idea at present of the vastness of the coal deposits in South Africa.

The resolution was carried unanimously, and acknowledged by Mr. Chiappini.

Lord Harris, in conveying the thanks of the Society to Lord Gladstone for presiding, said that

all those present felt honoured by his attendance, not only on account of his personal distinction, but on account of the great name he bore. Turning to the subject of the paper, one of the chief things that South African agriculture required for its development was water. Agriculture was of great importance to any country, because it was the one industry by which one could gain something without any further expenditure of capital. Precisely the same amount of money was spent on a farm whether the year was a good or bad one, but in a good year twice as much produce might be obtained from the soil as in a bad year. That was purely due to nature, and agriculture was the one industry which produced without an extra amount of labour an increased amount of produce. South Africa was finding out the reasons for the animal pests which had been such a bar to her progress, and was now exporting agricultural produce. The author had not paid much attention in his paper to the subject of forestry, except with regard to wattle. Forestry was not a matter that could be arranged in a few years, or even in several decades; one had to look a very long way ahead to establish a great forest industry, but he was sure both the author and the Chairman would agree with him that South Africa was greatly in need of an increase in her forests. A company with which he was connected had been doing its best to enlarge the forest areas in South Africa, without receiving much encouragement from the Union. He thought the Union should give every encouragement to the planting of large areas with forests, because there was no doubt that an increase of the forest areas would tend to increase the rainfall, which was so much needed for agriculture.

THE CHAIRMAN, in returning thanks, said that the Union Government had done a considerable amount of work with regard to afforestation, and hundreds of thousands of acres had been planted with trees, but he quite agreed that the work might be done on a much larger scale. The question of water was, of course, a difficulty, and meant the expenditure of more money. He thought everyone who visited South Africa agreed that all the vast areas of land unsuitable for other cultivation should be planted with trees, and he hoped that in time that would be done.

The meeting then terminated,

OBITUARY.

LIEUT.-COLONEL CLIFFORD PROBYN, D.L.—Lieut.-Colonel Clifford Probyn died at his residence in Regent's Park on the 10th inst., at the age of seventy-six. He represented the Strand Division on the London County Council, of which he had been a member since 1889. He was Mayor of Westminster in 1901–2, and one of His Majesty's Lieutenants for the City of London. He had been a member of the Royal Society of Arts since 1876.

GENERAL NOTES.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—The possibility of producing from home sources, hitherto neglected, a certain proportion of the vast amount of mineral oil and its kindred products, now so vital a necessity to our national existence, has been much canvassed for some time past in both the general and technical press, and at the next meeting of the Institution of Petroleum Technologists on the 19th inst., at 8 p.m., at the Royal Society of Arts, a paper will be read, dealing with the subject, and entitled, "A New British Oil Industry," by E. H. Cunningham Craig, Dr. F. Mollwo Perkin, Mr. A. G. V. Berry, and Dr. A. E. Dunstan. The President of the Institution, Mr. Charles Greenway, will occupy the chair.

COTTON INDUSTRY IN KOREA.—A company has been formed for the purpose of erecting a mill and carrying on a cotton-spinning and weaving industry in Korea. The capital of the company is 5,000,000 yen. The mill will spin fine yarns and manufacture shirtings from Korean upland cotton. According to the *Eastern Engineer*, it is hoped that the enterprise will prove much more profitable than similar undertakings in Japan, because of the local supply of raw material and of the cheap labour available.

MEETINGS OF THE SOCIETY.

(*Up to Easter.*)

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

FEBRUARY 20.—MAURICE B. ADAMS, F.R.I.B.A., "Picturesque Architecture." JOHN SLATER, F.R.I.B.A., will preside.

FEBRUARY 27.—SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

MARCH 6.—A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

MARCH 13.—PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] The ARCHBISHOP OF CANTERBURY will preside.

MARCH 20. — FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.:—

MARCH 14.—

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m.:—

MARCH 5. — GEORGE YOUNG, M.V.O., ex-Secretary of Legation, Lisbon, "Portugal as a Colonial Power."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.:—

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." Three Lectures.

Syllabus.

LECTURE I.—FEBRUARY 18.—*The Economic Condition of the United Kingdom before the War.* Population—Migration—Occupation of population—National production—National consumption—National wealth—Agriculture—Shipping—Investment of capital abroad—Balance of trade—Position of the United Kingdom in international trade before the war—National debt—National finances—Federal finance — General character of trade policy before the war.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEBRUARY 18...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. E. Crammond, "The Effect of the War on the Economic Condition of the United Kingdom." (Lecture I.)

Victoria Institute, Central-buildings, Westminster, S.W., 4.30 p.m. Mr. E. W. Maunder, "Sunspots and some of their Peculiarities."

Engineers, Cleveland Institution of, Corporation-road, Middlesbrough, 7.30 p.m. Mr. G. M. Brown, "Rolling-mills and their Electrical Equipments."

Geographical Society, Kensington-gore, W., 5 p.m. Mr. E. A. Reeves, "A Transformation of the Magnetic Dip Chart."

TUESDAY, FEBRUARY 19...Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Messrs. E. H. C. Craig, Dr. F. Mollwo Perkin, A. G. F. Berry and Dr. A. E. Dunstan, "A New British Oil Industry."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Mr. G. Drage, "Statistics of Poland and Lithuania."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "The Problems of British Anthropology." (Lecture III.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. 1. Discussion on paper by the Hon. Sir Francis J. E. Spring and Mr. H. H. G. Mitchell, "The West Quay of Madras Harbour." 2. Mr. A. Meade, "Modern Developments in Gas-works Construction and Practice."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Professor E. W. MacBride, "The development of *Echinocardium cordatum.*" 2. Captain G. D. Hale Carpenter, "An African Civet attacking Human Beings." 3. Mr. L. A. Lantz, "Reptiles from the River Tajan."

WEDNESDAY, FEBRUARY 20...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. M. B. Adams, "Picturesque Architecture."

Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Mr. F. A. Bellamy, "On the Barometer Record at the Radcliffe Observatory, Oxford, with special reference to Professor Turner's suggested discontinuities." 2. Dr. C. Chree, "The Diurnal Variation of Barometic Pressure at seven British Observatories, 1871-1882. A correction and some additions."

Geological Society, Burlington House, W., 8 p.m.

Electrical Engineers, Institution of (Local Section), University, Edmund-street, Birmingham, 7 p.m. Professor M. Maclean, "Kelvin as a Teacher."

Microscopical Society, 20, Hanover-square, W., 8 p.m. Professor B. Moore, "Photo-synthetic Action induced in Living Cells, and their Products." 2. Colonel Rawson, "Illustrations of Preparations."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Lieut.-Colonel L. W. Harrison, "The Management of Venereal Disease in the Civil Community."

THURSDAY, FEBRUARY 21...Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. J. B. Gatenby, "Notes on the Bionomics, Embryology, and Anatomy of certain Hymenoptera Parasitica, with special reference to *Microgaster connexus*, Nees." 2. Mr. W. B. Brierley, "Experimental studies in the specific value of morphological characters in the Fungi."

Chemical Society, Burlington House, W., 8 p.m. Lecture by Professor R. H. Strutt.

Royal Institution, Albemarle-street, W., 3 p.m Dr. E. Gosse, "Three French Moralists, and their Influence on the War — La Bruyère." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. W. Sanderson, "The Dolomites and Austrian Tyrol."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 5.30 p.m. Dr. C. C. Garrard, "Switchgear Standardisation."

FRIDAY, FEBRUARY 22...Royal Institution, Albemarle-street, W., 5.30 p.m. Mr. A. Clutton-Brock, "The Importance of Art."

University of London, Slade School of Fine Art, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture VI.)

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, FEBRUARY 23...Women Clerks and Secretaries, Association of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Problems in Atomic Structure." (Lecture II.)

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, FEBRUARY 22, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 25th, at 4.30 p.m. (Cantor Lecture.) EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." (Lecture II.)

WEDNESDAY, FEBRUARY 27th, at 4.30 p.m. (Ordinary Meeting.) SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, February 18th; Mr. JAMES SWINBURNE, F.R.S., in the chair. Mr. EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, delivered the first lecture of his course on "The Effect of the War on the Economic Condition of the United Kingdom."

The lectures will be published in the *Journal* during the summer recess.

ELEVENTH ORDINARY MEETING.

Wednesday afternoon, February 20th; Mr. JOHN SLATER, F.R.I.B.A., in the chair. A paper on "Picturesque Architecture" was read by Mr. MAURICE B. ADAMS, F.R.I.B.A.

The paper and discussion will be published in the *Journal* of March 15th.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers will be supplied, post free, for 2*s*. each, on application to the Secretary.

EXAMINATIONS.

The number of entries for the Examinations to be held in March is 10,712. Last year the number was 10,411.

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 6th, 1918; SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., Member of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Bamber, Herbert Kelway, M.V.O., Datchet.
Campbell, Donald Fraser, London.
Galpin, Stanley M. A., Aylesbury.
Gell, John, M.I.E.E., London.
Gridley, Charles Oscar, London.
Hinchley, Professor John William, A.R.S.M., Wh.Sc., F.I.C., London.
Murdoch, J. Alfred, London.
Parkes, Samuel Thomas Hickling, Birmingham.

The following candidates were balloted for and duly elected Fellows of the Society:—

Balston, Reginald M., London.
Beamish, Richard H., D.L., Cork, Ireland.
Beckett, Joseph Edge, London.
Dawson, Charles Williamson, London.
Dewar, James M., London.
Dyson, Sir Charles Frederick, J.P., Windsor.
Jack, Henry Joseph, North Wales.
Livingstone-Learmonth, Thomas Livingstone, London.
Love, Charles William Grosse, London.
McKnight, William Archibald, Chile, South America.
Miller, Hans Eric, London.
Sowrey, Major John, R.F.C., Newmarket.
Woodward, William Harrison, Farnham, Surrey.

The paper read was—

THE DEVELOPMENT OF THE MINERAL RESOURCES OF THE BRITISH EMPIRE.

By WM. FRECHEVILLE, A.R.S.M., M.Inst.M.M., Professor of Mining at the Royal School of Mines.

In attempting to deal with such a wide subject in a single paper, it is evident that only outlines can be touched on here and there; but even so the attempt seems worth making at the present time, when everything is undergoing searching scrutiny to see in what directions we may with advantage alter or amend our ways.

In preparing the following notes, mineral resources—other than coal and iron—have been specially in the mind of the writer, as it is with them he is specially acquainted, but he believes the remarks and suggestions made will be found, in many cases, to be also applicable to coal and iron.

Some of the points discussed relate specially to home mining, and others to the overseas parts of the Empire; but they are taken as they arise, the subject being approached from the standpoint that the mining industry of the Empire forms one great whole, and that what will help one part will help the whole.

It is assumed that the importance of these mineral industries may be taken for granted. It is common knowledge that they have played a very important part in our industrial development in the past, and not only have the direct products of the mining industry contributed to this, but the population attracted by it has afforded a needed and welcome market for the produce of such agricultural or pastoral countries as Australia and South Africa.

We know how important a part metals and the metal industries are taking in the present war, which has brought into prominent light an aspect of the question that has been almost entirely overlooked in this country heretofore. It is now seen that the possession of sources of the metals required in the manufacture of munitions of war is of great national importance, and that when it is attempted to draw up a list of these it appears that in some way or other they are nearly all required. This national need of the metals in times like the present becomes so insistent that other considerations, including that of cost, have to be put on one side.

With regard to the future, it is a matter of common belief that metals and the metal industries, including that of metal mining, will play an important part after the war is over, and this belief appears to be well founded, for not only will there be the waste of war to be repaired and reinstated, but the world generally has been obliged to go short, for the period of the war, of a great variety of things into the construction of which these metals enter, and there will be this accumulated demand to be dealt with. Over and above this there is the further fact that we shall have great financial burdens to bear, in order to pay the interest, and it is to be hoped some amortization, of our huge War Loans, and the most obvious way to achieve this would seem to be to speed up our activities generally, so as to produce more, and amongst other things to produce more metals.

The question then arises, what means appear to be most likely to produce this result of increasing the production of metals, and the endeavour is made in the following to suggest some answers to this.

Production can evidently be increased either by increasing the output of known mines, or by the discovery and opening up of new mines, and anything which promises to do either of these things may be regarded as worthy of careful consideration.

Dealing first with increased production from known mines, the most obvious and quickest stimulus would no doubt be that their working should yield good profit, and as for any given supply of ore this depends on cost of production and price of product, anything that reduces cost or increases the price of the product will tend towards the desired result.

With regard to cost, the efficiency of labour plays a very important part, and probably most metal-mine managers would agree with the view that their workmen could, without hurting themselves, accomplish a good deal more than they do. There is a general feeling that the men, even when working on contract, do not let themselves go to the extent they might, the explanation being that they often fear that if they do more, and in consequence make a good thing out of their contract, the price would be "cut" or reduced for the next monthly contract, with the result that they would have to work harder for the same wage. There is the further fact that the present system does not seem to bring out any community of interest between the men and the mine, and we all know how much better results can, as a rule, be got by anyone who is interested in the result and works with

his head as well as with his hands. These difficulties exist no doubt in other industries, and in some, perhaps, to a greater extent than in the metal-mining industry, and they probably constitute the principal industrial problem awaiting solution in the after-war days, when we hope many of the difficulties and shortcomings we are now keenly conscious of, will be seriously dealt with. This problem is evidently a very difficult one to solve, or someone would have hit on a solution ere now, but it is a very pressing one. On the one side are the men holding back, and on the other side increased working costs, and opportunities of production not being utilised to the full. To the writer it seems that probably the key of the situation lies in the fact that the men who do the work are not, perhaps, obtaining their fair share of the wealth they produce and of the good things that are going. Starting from that proposition, it appears that it should not be beyond the bounds of human ingenuity to devise some way by which, in conceding higher wages, more strenuous and intelligent labour should be obtained. In doing this it may be there would be found sufficient margin to ensure that the cost of production did not increase, and in any case we should obtain increased production and all it implies. It seems likely that in any case there will be a permanent increase of wages all round, and it would seem wiser to face this and to use the opportunity for obtaining increased efficiency, rather than allow the present unsatisfactory state of affairs to continue. The evidence that is available in the metal-mining industry does not point to high wages being necessarily followed by high cost of production. The United States, with high wages, show working costs per ton that compare favourably with other countries with much lower wages. In different parts of our own Empire we see the same thing: for instance, the costs per ton at Kalgoorlie in Western Australia, with a ruling rate for miners' wages of 13*s.* 4*d.* per day, have compared favourably with parallel costs in Mysore, with the rate for native miners at 8*d.* per day or thereabouts, the result being obtained by the greater efficiency demanded and obtained from the more highly-paid man.

Another possible way of reducing working costs, and also of reducing waste, is in finding out and introducing improved methods, and the recently established Committee on Scientific and Industrial Research should have a fruitful sphere of usefulness ahead of it. Some might be inclined to argue that an inventor is born and not made, and that his achievements cannot be controlled; but although there is probably a good deal of truth in this as regards abstract discoveries, it does not apply to the same extent to the inventor who designs new appliances, or works out new applications of known laws. Granted that the inventor is a specially gifted man, there is no reason why his gifts should not be directed into certain promising channels, and if an increased scope for investigating and inventive gifts existed, we should probably find that they are not so rare as is sometimes supposed. The possibility of "an invention to order" seems to be certainly proved in the domain of industrial advance, or else why do some large firms, notably some large foreign chemical manufacturers, keep a staff of skilled experts working out improvements of method or apparatus? In mining, too, typical discoveries to order may be cited. There is the well-known case of the Davy safety lamp, invented by Sir Humphry Davy in response to an appeal to help the coal-miner, who had to work exposed to the dangers of explosive gases. The McArthur-Forrest gold extraction process may be quoted as another instance. A Glasgow company, called the Cassel Gold Extraction Company, was formed to acquire a gold extraction process, which unfortunately did not prove a success. A chemist working for this company, Mr. J. S. McArthur, and two brothers, Mr. Robert and Mr. Wm. Forrest, took up the research to see if they could find some solvent of gold that would answer, and Mr. McArthur has described how they tried one after another all the solvents of gold they could think of, or of which they could find mention, with the result that the cyanide process which bears their name was evolved.

The instances cited also give an idea of the importance industrial inventions or improvements may have. If it were possible to appraise the value of the discovery of the Davy lamp to the industry of this country, it would, no doubt, be found to be a very large figure. The same may be said of the cyanide process. The total gold production of the world is now close to a hundred million sterling—it is given as £96,000,000 for 1916—and the major part of this is mill-gold, that is, gold extracted from ore by crushing and subsequent treatment, in which the cyanide process plays its part. Previous to the introduction of this process, the total extraction from an ordinary gold ore, making use of all the refinements then known,

was about 82 per cent., the remaining 18 per cent. being lost in the tailings, whereas now, by the aid of cyanide, the extraction is about 92 per cent. of the contained gold.

It thus appears that in working in this field, the reward, from a national point of view, may be great, out of all proportion to the outlay.

Another direction in which much more assistance might with advantage be given to the metal-miner in England, is in the careful geological examination of the ground and the unravelling of such problems as might be useful to him. Geologists in this country for some reason have almost entirely ignored metal-mining. Whatever the reason may be, this attitude is surely a great mistake, and one which must have worked as a serious disadvantage both as regards progress of our knowledge of the geological side of mining, and also to the industry.

Speaking generally, the policy in this country in the past has been to leave nearly everything to private enterprise and endeavour. While not wishing to advocate what is sometimes called "spoon-feeding," and frankly acknowledging that in some directions the policy has been justified by the results, one cannot help raising the question whether we have not carried the practice of Government aloofness too far.

Take the case of the Cornish tin-mining industry. The price of tin is abnormally high just now, which has put the industry on a securer basis than it has occupied for a long time past, but one has only to travel over the county and see the remains of former mines and mining operations, to realise that the industry has been a decaying one. In fact, there have been periods during the last decade or two when it has appeared to be almost in danger of extinction. Beyond the direct loss which would be caused by the cessation of production, attention may be drawn to the important *rôle* Cornish miners and foremen have played in the development of metal-mining throughout the Empire, and one cannot but think that an effort to rehabilitate the industry is well worth making. It would have to be made on wise lines, however, or it would be likely to do more harm than good.

Metal mines in England are frequently carried on under the terms of a mineral lease, the usual terms of which are that the mine is taken from the landowner for a limited number of years, subject to the payment of a rent and certain royalties. It may be pointed out that a lease of this kind does not seem a particularly happy basis on which to carry on an industry like mining, requiring the expenditure of large sums of money in such things as plant, buildings and shafts, and, moreover, the insecurity of tenure must act as a severe hindrance, particularly towards the end of the term. It may further be pointed out that the rent or royalties have to be paid before those who risked their money in the mine can receive any dividends, and also that when, as is sometimes the case, the royalties are exacted from mines which are not paying, their incidence is severely felt. Development of the known ore-bodies and exploration or search for new ones are the very life-blood of metal-mining, and if they are neglected, all but the exceptionally rich mines will languish and fail. When a mine is in a non-paying condition it is doubly necessary that development and exploration should not be neglected, and when royalties are exacted under these conditions money is diverted that would otherwise be available for this purpose, and diverted at a time when it is very difficult for those working the mine to replace it. If the owner could only be got to see the matter in its proper light, it is really a short-sighted policy to exact royalties under these conditions, as the result of doing so may very likely be detrimental to his own interests.

Another direction in which those who work metal mines suffer is in the incidence of income tax. As is well known, a metal mine does not go on indefinitely, but as the ore is extracted it is not replaced, and sooner or later the mine is worked out or exhausted. The profits that are paid should, therefore, properly be regarded as partly interest on the investment and partly as return of capital. Income tax as now levied takes no cognisance of the fact that the mine is a wasting asset, and demands and takes its toll from the capital as it is returned, as well as from the interest. As long as the income tax was a shilling, or a little over, in the pound, the hardship did not press severely; but now that it has risen to five shillings in the pound it is distinctly a case for inquiry, and it is to be hoped that the application which is now being made to the Government by representatives of the industry concerned may result in an equitable adjustment.

From the above statements it will appear that while little assistance has been given to home metal-mining, it has in some respects been hardly treated, and although it is not contended that this alone is the sole cause of its present state of decadence, still it has, no

doubt, contributed to that result. The industry generally, it must in fairness be stated, has also to struggle against two great natural difficulties —increase of depth and falling off in value, but these, it may be pointed out, are not necessarily fatal maladies at any particular stage. The depth is not so great as that at which metal mining is successfully carried on in some other parts of the world, and as regards falling off in value, although this is an ill which is hard to fight when it comes with increasing depth, still ore-deposits notoriously vary from time to time, and there may well be, and probably are, in some cases rich bodies of ore awaiting the attack of the miner underneath or by the side of the present impoverished workings of some of the mines.

Having in the foregoing touched very briefly on certain difficulties and handicaps which at present are rather pressing on the home metal-mining industry, let us pass on to consider the possibilities for expansion in mining which undoubtedly exist, particularly in the overseas parts of the Empire. Looking at the Empire as a vast estate, large parts of which still await exploration and development, the first and obvious step would appear to be to find out what we have. While encouraging exploration and prospecting by others, it is suggested the estate owner should himself take some active steps in the matter, and, by means of the examination of the country by skilled men, ascertain the importance of known mineral discoveries, the most likely ground for prospecting, and generally the wisest policy to pursue to encourage the mining industry for the good of the community. In our Crown Colonies this should be done under the control of the Home Government. In other parts of the overseas Empire the Governments of the great Dominions already give much attention to the development of their mineral resources, but the territories they administer are so huge there is ample scope for doing more if the means were available.

An Imperial Mineral Resources Bureau is, it is understood, now being formed, and to aid in the above developments would appear to be one of the many useful and important functions that a wisely constituted bureau might perform.

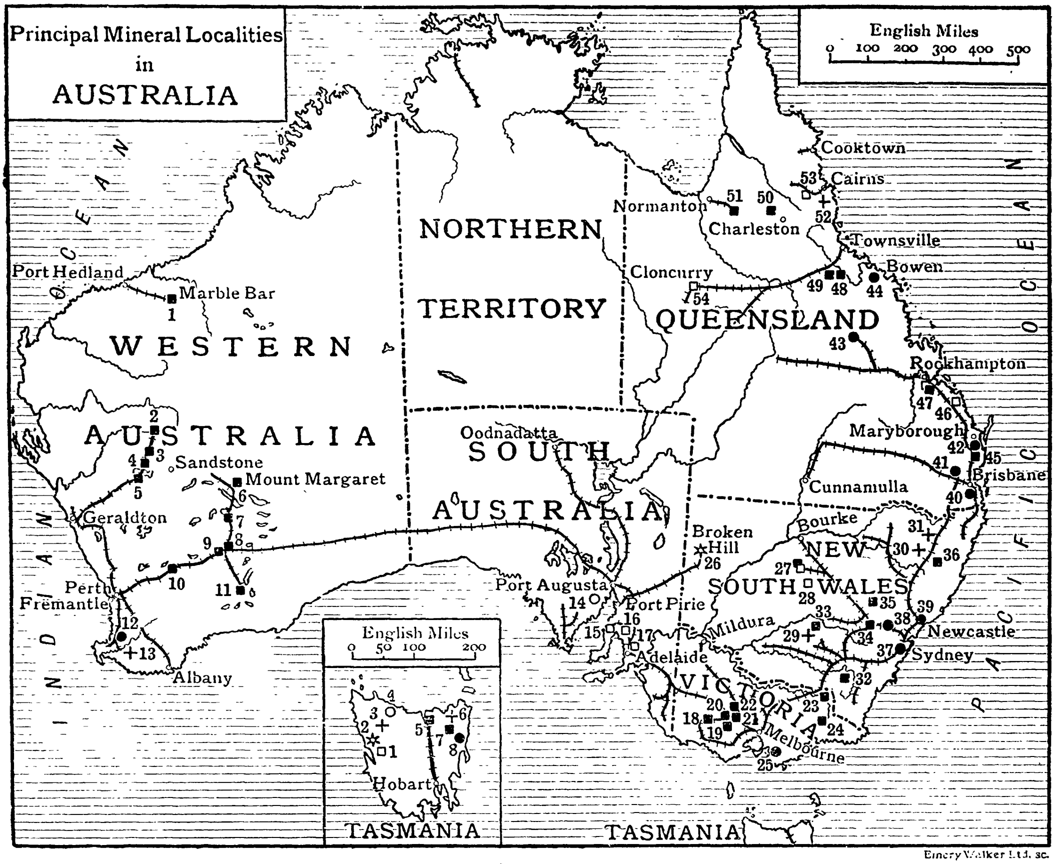
It is to be hoped this bureau when established will be on a thoroughly wide and comprehensive basis, and that the great Colonies will be adequately represented.

It is not possible within the limits of this paper to illustrate as fully as it deserves the contention that there is great scope for expansion in the overseas parts of the Empire, but in the short time at our disposal three instances may be mentioned, and these will be taken from Ceylon, a Crown Colony, and Australia and Canada, great self-administering Dominions.

Ceylon, as is well known, produces a considerable part of the plumbago or blacklead consumed by the world in the manufacture of crucibles for the metal industries, and for other useful purposes. The industry is quite an important one, as in the pre-war years the annual export of plumbago from Ceylon was valued at about half a million sterling, and constitutes about one-third of the total production of the world. In spite of its importance, however, it is rather humiliating to note that no adequate geological study of the occurrence of plumbago in Ceylon, or technical study of the methods of mining and preparation, appears to have been made. This is certainly not in line with the methods that are adopted in other countries which take a closer interest in the development of their mineral resources. It is suggested that the whole subject—geological and technical—should be carefully studied by competent men and described in a monograph, and compared with plumbago occurrences and methods of working elsewhere. In this the industry concerned might gain valuable information, and outside people would have an opportunity of judging as to what opening there may be there for their enterprise or special knowledge.

The plumbago industry in Ceylon appears to be carried on entirely by natives, and, from what one can learn, in a very primitive way. A similar state of affairs used to exist in the tin-mining industry in the Straits Settlements, where of late years considerable advantage has been gained in the direction of working poor deposits by improved methods and machinery.

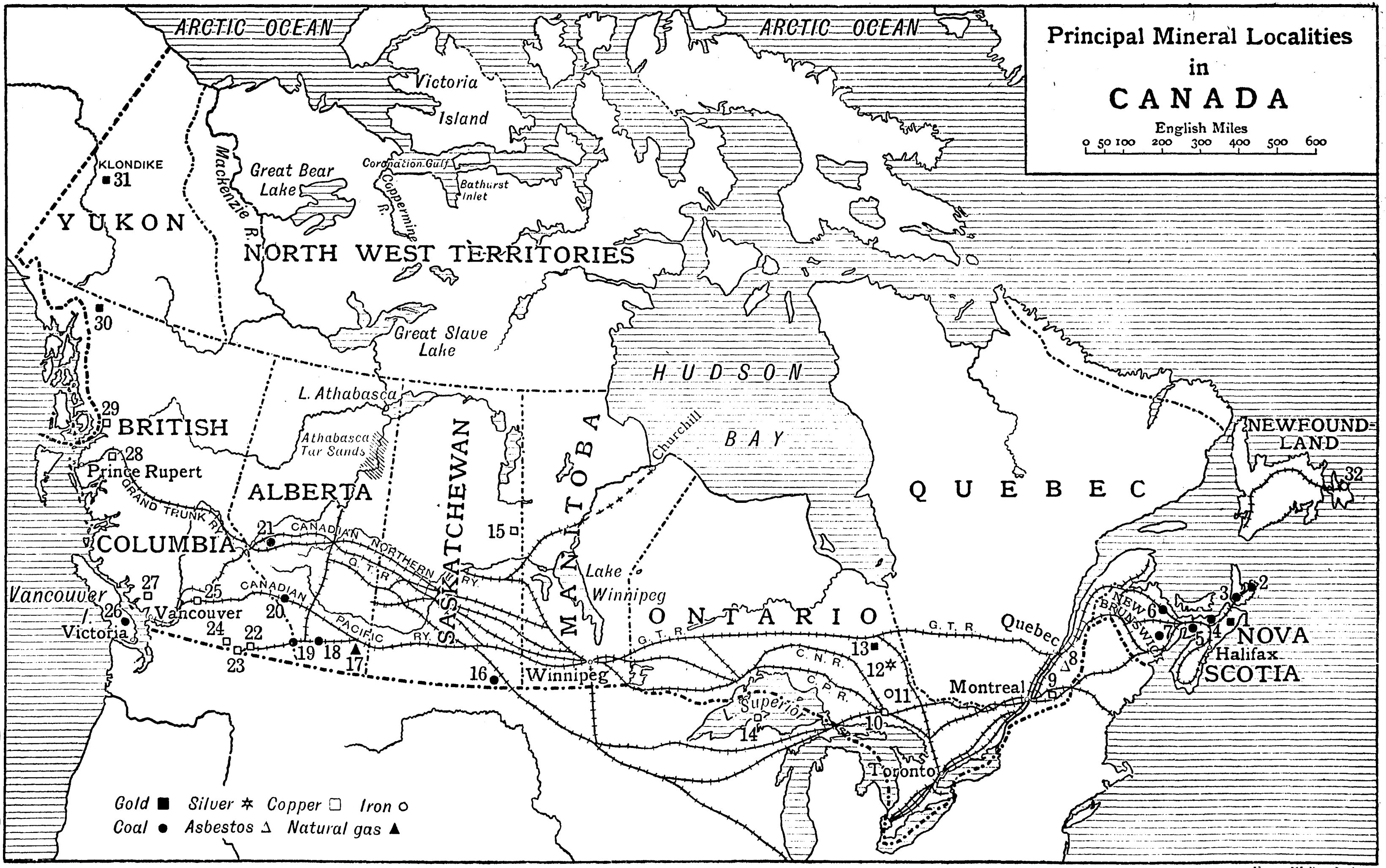
With regard to Australia, the second instance cited, attention is directed to the map on page 250, which illustrates the distribution of the principal known mining centres in that great island continent. Commencing with Western Australia on the one side, and passing round by South Australia, Victoria, New South Wales, and Queensland, it is seen that the known mining centres, which are indicated on the map by a dot, all follow round the coastlands up to, say, from three to four hundred miles inland; that is to say, they are in the strip or zone of country that has



Gold ■ *Copper* □ *Silver-Lead* ✲ *Tin* + *Iron* ○ *Coal* ◉

been travelled over and prospected. Beyond this there stretches a very little known interior, with no mines working and no dots on the map. Looking at this diagram broadly, and taking into consideration the plentiful way in which the dots are sprinkled over the country near the coast, and how they are absent in the interior and in the little known Northern Territories, one cannot avoid the conclusion that the absence of mines in these parts is not so much due to the absence of mineral wealth as to the fact that the country is still largely unprospected.

The same reasoning may be applied to Canada, the mining centres of which are shown on page 251. In this case the producing mineral districts are seen to follow the railways in a curiously persistent way; in the first instance the great east and west transcontinental railways, and then the north and south branches. In Australia the mineral discoveries have been made first, and then railways have been constructed to connect them with the coast, but in Canada, as a rule, the railways have been built first and then mineral discoveries have been made either on the line of railway or not far off. The explanation of this lies in the climatic history of the two countries. In Australia the fragments of ore which break off from where the valuable mineral "crops out," or comes to the surface—which is called "float" by the miner—lies about and is not difficult for the prospector to find, whereas in most parts of Canada the surface has been planed off by the great glacial sheet which at one time covered the land, and the chips or fragments that have been planed off have been ground to powder by the movement of the ice-sheet, and carried away and distributed perhaps hundreds of miles from their source. In consequence of this the "float" is not there to aid the prospector, and the normal condition is that under a few inches or a few feet of moss or glacial clay the smooth ice-worn unweathered rock is found, and if there are mineral veins or deposits in it they are hidden by the moss or soil, and do not actually appear on the surface. This makes prospecting more


Principal Mineral Localities
in
CANADA
English Miles
0 50 100 200 300 400 500 600
ARCTIC OCEAN
ARCTIC OCEAN
Victoria Island
Coronation Gulf
Bathurst Inlet
Coppermine R.
Great Bear Lake
Mackenzie R.
KLONDIKE
31
YUKON
NORTH WEST TERRITORIES
30
Great Slave Lake
HUDSON
BAY
Churchill
L. Athabasca
Athabasca Tar Sands
29
BRITISH
28
Prince Rupert
GRAND TRUNK RY.
ALBERTA
21
COLUMBIA
CANADIAN NORTHERN RY.
G. T. R.
SASKATCHEWAN
15
MANITOBA
Lake Winnipeg
QUEBEC
NEWFOUNDLAND
32
27
Vancouver I.
25
Vancouver
26
Victoria
24
22
23
CANADIAN PACIFIC RY.
20
19
18
17
16
Winnipeg
ONTARIO
G. T. R.
G. T. R.
C. N. R.
C. P. R.
13
12
11
10
14
L. Superior
Toronto
Montreal
9
8
Quebec
NEW BRUNSWICK
6
7
5
4
3
2
1
NOVA SCOTIA
Halifax
Gold ■ Silver ✱ Copper □ Iron ○
Coal ● Asbestos △ Natural gas ▲
Emery Walker Ltd. sc.

difficult in Canada than it is in countries which have not been glaciated or ice-worn, and it also accounts for the fact that, until comparatively recently, Canada seemed to be behind other parts of the Empire in mineral wealth.

A general examination of the diagram of the principal mining centres of Canada will lead to very much the same conclusion as was indicated in the case of Australia. The mining centres are scattered through the known and prospected belt of country stretching from east to west, and the fact that they are absent in the little known and almost quite unprospected great northern country is in all probability not due to their non-existence, but to their not having yet been found.

In one part of this little-known northern part of Canada there is already evidence of the existence of copper over a large area. Specimens or nuggets of native copper were first obtained from the Esquimaux, who used the metal for their implements, and the occurrence was subsequently confirmed by the few travellers who have been in that region; and it is interesting and significant to note that the specimens of rock which have been brought from these, point to the occurrence being geologically similar to that of the highly productive and profitable copper-mines of the Lake Superior district of the United States.

The new copper district referred to is situated east of Great Bear Lake and along the course of the Copper Mine River, which runs north from about Lat. 65° into Coronation Gulf in the Arctic Ocean. Evidences of the occurrences of copper are also reported as far east as Bathurst Inlet, and on Victoria Island. Amongst others, the Canadian traveller and geologist, J. B. Tyrrell, has drawn attention to this possible copper-field, and the broad facts as stated may be taken as established. The present position may be summed up by saying that there may be a great copper-field somewhere in that region awaiting development, and that the locality is worthy of being carefully examined and prospected both from a Canadian and from an Imperial point of view. Its rigorous climate, remote position, and the difficulty of access, have hitherto stood in the way of this being done. It would require a summer to go, another summer to make a preliminary examination, and a summer to return — say two and a half years in all to make even a preliminary survey. Even so, the economic and national importance of a great copper district would seem amply to justify the effort.

It may be mentioned that Arctic conditions are no bar to successful mining operations, as the mines of the Klondike are in Lat. 63° to 65°, and the Sulitelma copper-mines in Northern Norway, and the Gellivare iron-mines in Swedish Lapland, are both within the Arctic Circle.

With regard to access for examination, in view of what is taking place around us, it does not require much, if any, expansion of what has already been done, to allow aeroplanes to be considered as a possible help, particularly in view of the fact that the numerous lakes in that region would appear to facilitate the establishment of landing and supply stations.

One of the features of the times through which we are passing has been the high prices commanded by the various metals when free of Government control. The metal, copper, for instance, commands now a price of about £110 a ton, against about £60 in ordinary times, and no doubt the purchases of the large requirements of the Government have to be made at somewhere about the higher figure. Perhaps we shall learn the exact figures relating to these purchases some day, and it would not be surprising if perhaps the excess profits—that is the extra profit due to war conditions—made by the American copper producers on one deal alone would suffice, or more than suffice, to construct a railway such as would be required to open up the part of Canada referred to, remote as it is.

The obvious objection to the suggestion that Governments might, with advantage, adopt a more active policy in developing their mineral resources, would be on the score of expense. Two answers to this suggest themselves—one being that the expansion of the mineral industry would be of great benefit to the country and Empire, and the other that in cases where Government aid had been given, and public funds expended, it might seem only fair that the Government or Governments should participate in some form in the result, if successful. One solution of the problem how this may be done is being worked out by the South African Government in connection with the Far Eastern Rand Gold Mining Areas, which are now, from time to time, being put up to public tender. The basis on which the tenders are made is that a share of the profits, calculated on a sliding scale, has to be paid to the Government, and the one who offers the greatest share obtains a lease of the ground for the life of the mine,

subject to the conditions of the lease being fulfilled. The system appears to be a fair one, and to be working well.

In the foregoing the writer has made suggestions here and there of action which, it appears to him, would aid the development of our mineral resources, and has quoted cases which illustrate the views he has in mind. No attempt has been made to cover the ground, but the writer hopes enough has been said to establish the soundness of the view that a good deal might well be attempted in several directions, with a reasonable assurance that the results would justify the attempt.

DISCUSSION.

THE CHAIRMAN (Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.), in opening the discussion, said it was of vital importance to the British Empire that the population of its Colonies should be much increased. At the present time the population of the British Isles was about 46,000,000, whereas there were only 16,000,000 people, excluding the native inhabitants, in the whole of the rest of the Empire, including Canada and Australia. The population did not rapidly increase in a purely agricultural country, but it did so in an industrial country; and it was greatly to be desired that both Canada and Australia should become important industrial countries. That could be brought about—given a sufficiently liberal policy on the part of the Governments and on the part of the people themselves—partly by means of mining and partly by an increased use of the water powers of the countries, particularly in Canada. It was a fascinating possibility that in the districts with which the author dealt, not only could minerals be obtained, but also the water power to work them, and possibly also the water power and mechanism for working them up into finished products by the electrolytic and the electro-chemical processes so much in vogue at the present time. It was necessary, as the late Professor Seeley said in his "Expansion of England," to have at least 50,000,000 people of our own race in the parts of the Empire outside the British Isles, in order to secure the greater stability of the Empire.

MR. OCTAVIUS C. BEALE said he was glad to hear the author's remarks on the immense possibilities of Canada and Australia, and also the hint he threw out that the mining industry of the British Empire formed one great whole, and that what would help one part would help the whole. The difficulty of getting the whole mining industry of the Empire represented in London would be very great; but, at any rate, the separate portions of that industry might be represented in London by an authoritative body, which could deal with their respective interests. There should be a Zinc Committee, a Copper Committee, and so forth, to embrace the whole of what was not only an important part of our industrial development and of great national importance, but was absolutely basic. The people of this country had to decide now whether they were going to let Germany resume her former position after the war, and keep a control over the metals of the British Empire. Australia produced 450,000 tons of zinc ores per annum, and before the war the whole of that went for refining to Germany, with the exception of about 20,000 tons, and the German vessels which conveyed the ores took out the necessary machinery for working the mines. Germany had acquired an enormous amount of control over the metals of Australia and Canada, and now that this country was going to alter that state of affairs it was essential, not so much that there should be a great increase of the European population in the Dominions, as that that increase should be of the British population only. He had been asked in America whether it would not be better for Australia if she had a very much larger population; but his answer was that Australasia produced as much gold as the whole of the United States, and that her 6,000,000 people who owned that gold were better off than the 100,000,000 people of the United States. Again, Australasia had 110,000,000 sheep for her 6,000,000 people, whereas the United States had only 50,000,000 sheep for her 100,000,000 people. Why should Australia introduce a number of immigrants, who would perhaps lower the standard of living and reduce the rates of wages, rather than go on producing, as she did produce, all the steel and zinc and the great bulk of the copper that the British Empire required, if only there were wisdom enough in the United Kingdom to see that those metals came to British people? They should be given first to the British Empire, and secondly to the Allies, and then the neutral and enemy countries might take the remainder.

SIR WILLIAM GREY WILSON, K.C.M.G., said that the difficulty of the income tax in connection with metal mines, to which the author had referred, could and should be remedied by the directors paying a considerable amount of the earnings of their companies into the reserve fund, instead of distributing it as income. Although it was very difficult for a man to set aside half his dividend and treat it as capital, he thought it would be a very useful thing to do in the case of metal-mining companies. With regard to the question of Government aloofness, he did not think anyone connected with any company could accuse the Government of that aloofness since the war broke out. The Treasury had exercised the most drastic supervision over every company that had been started, and he believed that control had been most satisfactory, and should be continued after the war to a certain extent. It would, of course, be impossible for the Government to declare that an

venture was absolutely sound; but it would be quite possible for the Government to put a stop to the wild-cat schemes that were sometimes floated, and that did so much injury to the genuine development of the mining industry, by saying that they were not companies with regard to which they could sanction the issue of capital. In that way the general public could be encouraged to invest their money in mining industries, which had at times been under a cloud.

MR. E. H. CUNNINGHAM CRAIG said it was well known that there was a certain number of petroleum fields in the British Empire, and it was also well known by those who were interested in them that their development had been rather unfortunate. In some places there had been a great delay in regulating them, and in other places there had been a great delay in getting them into working order. The colony of Trinidad, for instance, had a very promising oilfield, but it had taken years to get it into such a condition that the ordinary shareholder could reasonably expect to obtain dividends from the various companies. The reason for that was that there had not been enough British control nor enough Government control. He had been told that at one time the two great oil corporations of the world met in order to divide the world between them, to mark out their spheres of influence so that one should not interfere with the other. One of those corporations was controlled by the Dutch and the other by the Americans, and they were both interested to some extent, through subsidiary companies, in Trinidad. He did not know if they ever decided what should be done with Trinidad, but he thought they both determined that if they did not work the oilfields of Trinidad themselves they would make it as difficult as possible for anyone else to do so. The result was that the development of those oilfields had been kept back for many years, and he thought that was a very good instance to show the necessity of having entirely British control of British Empire resources.

PROFESSOR C. GILBERT CULLIS said the author had rightly pointed out that if the British Empire was to increase its output of minerals it must adopt one of two courses—it must either make better use of known deposits, or discover or acquire fresh deposits. With regard to the better utilisation of known deposits, he would like to call attention to the extraordinary extent to which raw materials, or partially smelted materials, of British origin were at the present time, and had been for the past few years, exported from British territory to foreign countries for the production of the finished metal or of the manufactured article. For instance, Quebec possessed the finest deposits of asbestos in the world, but only a very small proportion of those deposits was worked up into the finished asbestos article within the British Empire, most of the material being sent to the United States for that purpose. Again, only a small proportion of the diamonds obtained from the South African mines were actually cut and made into finished stones within the British Empire; and a still more notorious instance was that of the zinc concentrates of Broken Hill. Before the war, some 500,000 tons of these concentrates were produced annually, of which only a few thousand tons were smelted in Australia and about 20,000 tons in England, the whole of the remainder going to Germany and Belgium for the extraction of the zinc metal. Nearly all the copper and nickel deposits of Ontario were sent to the United States for the extraction of the metals. That export of raw materials had two disadvantages. In the first place, the benefits in wages, in skilled labour, and in increased profits which attended the working up of a finished metal from an ore were lost to the British community; and, in the second place, the control of the finished metal or manufactured article, and the art of producing it, which was equally important, passed into alien hands. Our aim in the future should be to ensure that all British raw materials were treated within the British Empire, the finished products being exported rather than the raw materials. With regard to the discovery of fresh deposits, if such a discovery was to be made within the next few years, both the home Geological Surveys and and the colonial Geological Surveys must be greatly speeded up. Their staffs must be augmented, and those staffs must be composed to a certain extent of men who, besides having been thoroughly trained in the fundamental principles of geology, had also a sound knowledge of mathematics and a working knowledge of metallurgy. The results obtained would then, from the point of view of practical geology and the production of minerals, be very much better than they had been in the past.

MR. C. H. B. BURLTON said he would go a step further than the previous speaker, and not only confine the utilisation of the raw materials produced in the Empire to the various countries within the Empire but to the actual country in which they were produced. Unless the Government of a Dependency provided manufacturing industries therein, exportation to other countries would, as at present, be inevitable. He had been very much struck by the great disparity of wages that prevailed in different parts of the world, as indicated by the author. Miners' wages in Western Australia were given as 13*s*. 4*d*. a day and in Mysore at about 8*d*. a day, but he understood from the paper that the efficiency was fairly proportionate to the wages. He thought that if an Indian labourer turned out work to the value of 13*s*. 4*d*. a day and received that amount for it, he would think he had quite sufficient money to last him for a week, and very likely would not do any more work for the rest of the week. The remarks made in the paper with reference to the plumbago industry in Ceylon were very interesting. The industry in Ceylon was an important one, because it comprised about a third of the world's output of plumbago, and it was

certainly not very creditable to the Government of Ceylon, or whoever was responsible for the matter, that there was not more geological interest taken in the resources of that island especially with regard to plumbago. The mineral resources of India had been largely left to private enterprise, the Government granting a concession and then leaving the concessionnaire to sink or swim. That was not as it should be, and it was also inconsistent with what the author had said about expanding the mineral industry with a view to benefiting the countries from which the minerals were derived. India was very badly off for fire-bricks, but her mineral resources were such as to justify the erection of very large kilns for the calcination of fire-bricks by the Government. If such kilns were erected, not only would the Government be supporting the industries already in existence, but other industries would be created and there would be an enormous demand for fire-bricks, and all the manganese which at present went out of India would be utilised in that country. The iron ore would also be used, and there would be ironworks erected all over the country to utilise the materials derived from the mines in India.

Professor Frecheville, in reply, said that the difficulty in trying to develop the resources of Canada in the country of their origin, was that Canada was next door to the United States. The mining people in the United States were watching very closely everything that was found in Canada; they had plenty of money and plenty of enterprise, and unless steps were taken to prevent them doing so, they would probably get control of all the different deposits in Canada as they were discovered. A very large copper mine had recently been discovered in Manitoba, which had been proved to contain about six or eight million tons of ore of a low grade, but still profitable if worked on the huge scale on which the Americans worked their copper mines. £1,000,000 was required to work that mine, £500,000 for the railway and £500,000 for the plant. The people of Canada could not provide that money, and probably people in Great Britain would not care to do it, and the only people who really understood the working of those huge copper deposits were the Americans. The Government was being asked to do a great deal, and if they rose to the occasion they might do it, in which case they would pay themselves for it, and there was no reason why they should not. For instance, the South African Government was now offering mining areas on the Far Eastern Rand to tender; anyone could tender for them, and the ground was given to the man who offered the largest amount, the Government taking a share of the profits on a sliding-scale. He did not see why other parts of the Empire should not adopt the same system.

The Chairman then proposed a vote of thanks to the author for his interesting paper. An important fact to be borne in mind was that it was easier to obtain money for a gold proposition than for any other kind of mining. The total production of gold in the world was only £100,000,000 per year, which did not amount to one-twentieth of the income of Great Britain itself in one year. Gold was a very small part of the wealth of the world, and Canada and Australia should attach more importance to population and less to gold and minerals. The real wealth of the world depended on population alone, and as long as Canada and Australia had such small populations they would remain as poor as they were at present. Great Britain had the largest income per head of its population of any country in the world, with the exception of the United States.

The vote of thanks was carried unanimously and the meeting terminated.

Mr. Hugh Pearson writes:—The Chairman at the meeting on the 6th inst. accurately defined Professor Frecheville's paper when he said it was a suggestive contribution to a great subject, and it was a pity that time did not permit the Professor to develop his points thoroughly, and for a more complete discussion afterwards. As it is, he has given a lead, yet I cannot help thinking that a less comprehensive title would have been more in keeping with the scope of the paper. To exclude coal, iron, and petroleum from a discussion of the mineral resources of the Empire is to neglect three of the greatest necessities of the present age. It is to the first two that we owe, in a large measure, our greatness in the past. No country without motive power can become truly great, and something of this kind was evidently in the Chairman's mind when he referred to the possibilities of the water-power resources of Canada. And Germany recognised the value of iron in her determination to hold the stolen provinces of France. Unlimited cheap supplies of iron ore are the very life-blood of the nation. As for the third—petroleum—who would set limits to its possibilities? Our present strong position in the war has only been possible because of this great gift of nature. And in view of this fact I am not surprised that Mr. Cunningham Craig voiced his disappointment at no mention being made of its presence in the Empire, and no suggestion being given for the more active search for, and development of, known resources. It is true Mr. Frecheville said that the aeroplane might solve some difficult transport questions as he passed his pointer over the map of Canada from British Columbia to the Arctic Ocean, where, he said, deposits of copper ore exist. This is no fantastic suggestion. The progress of aeronautics during the war is convincing evidence that the future will see wonderful developments in this direction, but Mr. Frecheville lost a point to emphasise an argument when he failed to mention that in the intervening space traversed by his pointer there are large areas impregnated with desiccated petroleum, which some authorities believe will yet prove a mask to the presence of

valuable deposits of petroleum; and should this be realised, Mr. Frecheville's aerial transport order would find supplies *en route*, and probably a source of wealth infinitely greater than the original object of flight. It is to be hoped so at any rate, because, as it is, our position as producers of petroleum is not flattering to our national vanity. The Germans make rings round us all the time, and we generally realise the fact when it is too late. Take the Baghdad railway. We are told that it was being pushed eastward to increase German influence, and ultimately enable them to take our place in the East. This undoubtedly is true, but was there not another and a more immediately profitable object in view? Germans were amongst the first to explore the ruined cities of the ancient world, and claimed a good deal of credit for disinterested antiquarian research, but the fact is they scented oil, and have long been conscious of the petroleum possibilities of Mesopotamia, and had the war only been delayed a little longer, we should once more have found out how deep-laid and cunning were the schemes of our enemies. The action of the Government in stepping in to help the Anglo-Persian Oil Company was a bitter blow to them, and now that something of the facts are known, the public should be less hostile to the Government enterprise and keep their eyes on Mesopotamia. In conclusion, I wish to say that I heartily endorse all that Professor Frecheville said, and had space not been so valuable, I would have given some personal examples of my experience in further proof of his conclusions.

Professor Frecheville writes:—I have read Mr. Hugh Pearson's remarks, and quite agree with the views he expresses. I confined myself, for the time at my disposal, to the aspects of the question with which I am personally familiar, but fully admit that the consideration and discussion of the general lines that should guide us in developing our resources in coal, iron, and petroleum, would be very useful at the present time.

CORRESPONDENCE.

THE TATA IRON AND STEEL WORKS.

In the course of his paper on the above subject, published in the *Journal* of February 1st, Mr. H. M. Surtees Tuckwell gives the capacity of the Tata Works, and further on in the paper states that "the tonnage of pig-iron and steel corresponded approximately to that of the Frodingham Iron and Steel Company of this country."

As our outputs both of iron and of steel are very considerably larger than the figures given by Mr. Tuckwell, we shall be greatly obliged if you will correct this statement in your next issue.

Frodingham Iron and Steel Co., Ltd.

With reference to a letter from the Secretary of the Frodingham Iron and Steel Co., Ltd., taking exception to a comparison between the Tata Iron and Steel Works in India and the Frodingham Iron and Steel Company in this country, it would appear that the Secretary of the latter company has misunderstood the meaning which it was intended should be conveyed in the paper read before the Royal Society of Arts.

In this paper it is remarked that considerable enlargement had been decided upon, and that tonnage of pig-iron and steel consequent upon such enlargement corresponded approximately to the Skinnigrove and Frodingham Iron and Steel Companies of this country.

The contemplated outputs which the writer had in mind when making the above statement have been considerably expanded in the meantime, and when the extensions are completed, an output of 665,000 tons of pig-iron, 14,000 tons of ferro-manganese, and 656,000 tons of ingot steel are intended to be manufactured yearly.

It is much regretted if any annoyance has been caused to the Frodingham Iron and Steel Co., Ltd., and we trust that the above explanation will be entirely satisfactory to them.

Tata, Ltd.

OBITUARY.

The Hon. Rowland Gibson Hazard.—Information has been received of the death of the Hon. Rowland Gibson Hazard, which took place at Santa Barbara, California, on January 23rd. He was born at Philadelphia in 1855. After graduating in Arts at the Brown University (of which he subsequently was a Fellow) he went into business. In 1888 he became Vice-President of the Solvay Process Company; in 1890, President of Semet-Solvay Company; and in 1898, President of the Peace Dale Manufacturing Company. He was also a member of the Providence Harbour Improvement Committee. In addition to his business activities, he took a deep interest in various charitable and scientific institutions. He was a trustee of the Rhode Island State Sanatorium for Consumptives, and a member of the Linnean Society (New York), the National Association for the Study and Prevention of Tuberculosis, the American Forestry Association, the Franklin Institute, the American Ornithologists' Union, and other bodies. He joined the Royal Society of Arts in 1910, and took a very friendly interest in its welfare. From the outbreak of the war his sympathies were very strongly pro-Ally, and he devoted himself to propaganda work among his countrymen.

GENERAL NOTES.

Röntgen Society.—At a meeting of the Röntgen Society, held on February 5th, Mr. Batten read a paper on a simple means of obtaining "Static Currents" from an induction coil. The method consists in connecting one secondary pole of the coil to earth, whilst the other is connected

through a series spark-cap, oscilloscope tube, and a series condenser to the patient, who is placed on an insulated stand. The function of the condenser would appear to be that of a high resistance. The advantages of the apparatus are twofold. In the first place, it overcomes the troubles due to a wet climate, from which the static machine always suffers, and, secondly, it affords an inexpensive means, to those already possessing an induction coil, of obtaining currents similar to those produced by static machines.—Mr. E. E. Burnside read a paper describing a new mobile Snook apparatus. This is constructed on the same principle as the larger pattern hitherto in use, but is made in a more compact form by reducing the maximum spark-gap to 7 in.—Mr. Burnside also showed a small transformer constructed for employing the continuous current main supply to heat the spiral of the Coolidge tube. A small rotary converter changes the direct current into alternating current, which is stepped down to 12 volts by the static transformer: the secondary is well insulated from the rest of the apparatus, and regulation of the filament current is obtained by a variable choke-coil in the primary circuit of the transformer.

SEA-LEOPARD, WEDDELL-SEAL, AND PENGUIN OILS.—In a report presented to the Imperial Institute Committee for Australia on the recent work of the Institute for the Commonwealth, particulars are given of the results of an investigation into a series of oils prepared during the Australasian Antarctic Expedition and forwarded to the Institute by Sir Douglas Mawson. These materials included sea-leopard oil, Weddell-seal oil, and penguin oil. They have been carefully examined in the Scientific and Technical Department of the Imperial Institute, in order to determine their characters in comparison with commercial oils of a similar kind, and have also been submitted to buyers of such oils in the United Kingdom. The oils were of good quality, and could be utilised for the purposes to which commercial seal and whale oils are applied, viz., for soap-making, leather-dressing, burning, etc. There is no doubt that there would be a ready sale for consignments of any of these oils at about the current price of whale and seal oils if they should become availabe in commercial quantities.

WAX FROM SUGAR-CANE.—Wax, for some time past, has formed one of the by-products of the sugar industry in Natal, and its manufacture, according to the *South Africa Journal of Industries*, is now making very active progress. The process (which is patented) is somewhat intricate, but the treatment applied to an otherwise waste product (filter press cake from the sugar factories) results in the production of a very fine, hard, vegetable wax practically equal in value to Carnauba and beeswax, with which latter it is, chemically, almost identical. The wax has a high melting-point and takes a very high polish. After the extraction of the wax the large residue forms a fertiliser which is used entirely by the sugar estates forwarding their filter press cake for treatment. A refining plant has been equipped for treating crude wax for export, and for supplying an apparently general demand by manufacturers of furniture and boot polishes in the Union. About 250 tons of this wax have been shipped to London during the past two years, and the demand appears to be unlimited.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

FEBRUARY 27.—SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence), "The Organisation of Commercial Intelligence." The RIGHT HON. LORD FARINGDON will preside.

MARCH 6.—A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

MARCH 13.—PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] The ARCHBISHOP OF CANTERBURY will preside.

MARCH 20.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

APRIL 10.—W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "The Cotton Industry."

APRIL 17.—PERCY SHUTTLEWOOD, Ministry of Food, "The Food Situation in Germany."

APRIL 24.—MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War."

MAY 1.—GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

MAY 8.—JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry."

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

MARCH 14. — WILLIAM FOSTER, C.I.E., "English Commerce with India, 1608–1658."

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India."

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoons, at 4.30 p.m.:—

MARCH 5. — GEORGE YOUNG, M.V.O., ex-Secretary of Legation, Lisbon, "Portugal as a Colonial Power."

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. (unless otherwise announced):—

EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." Three Lectures.

Syllabus.

LECTURE II. — FEBRUARY 25. — *The Economic Condition of the United Kingdom after Three Years of War.* Transformation from peace production to war production—Position of women in commerce and industry—National production—National consumption—Inflation of currency—Rise in the cost of living—Rise in the prices of raw materials—Government control of labour, commerce, agriculture, shipping, etc.

LECTURE III.—MARCH 4.—*The Real Cost of the War and the Problem of Economic Reconstruction.* War expenditure of the British Government —War debt — Pensions — Education — Imperial Revenue and expenditure — Excess profits duty —Levy on capital—National debt after the war —Economic reconstruction — Problems of demobilisation—Commercial relations of the United Kingdom with the Empire and our Allies—Interaction of International trade and finance on the economic life of the United Kingdom — The investment of capital abroad.

J. YOUNG, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEBRUARY 25...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. E. Crammond, "The Effect of the War on the Economic Condition of the United Kingdom." (Lecture II.)

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m. Captain D. Bowen, "The Effect of Taxation on the Development of Mineral Estates."

Geographical Society, Burlington-gardens, W., 8.30 p.m. Le Comte Renauld de Briey, "A Recent Visit in East Africa."

TUESDAY, FEBRUARY 26...Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Lieut.-Commander H. T. Harrison, "A Survey of Methods of Directing and Concentrating Light."

Royal Institution, Albemarle-street, W., 3 p.m. Sir Richard T. Glazebrook, "A National Laboratory of Industrial Research." (Lecture I.)

WEDNESDAY, FEBRUARY 27...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Sir William Clark, "The Organisation of Commercial Intelligence."

Colonial Institute, Caxton Hall, Westminster, S.W., 4 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Lady Barrett, "The Rôle of Midwife in relation to the Nation's Health."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Professor M. A. Gerothwohl, "A Great Spanish Humorist (Armando Palacio Valdés)."

THURSDAY, FEBRUARY 28...Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. E. Gosse, "Three French Moralists and their Influence on the War — Vauvenargues." (Lecture III.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Dr. G. H. Rodman, "The Domestic Fly—its Habits, Structure, and Menace to Health."

Britain and India Association, 33, Regent's Park-road, N.W., 4 p.m. Mr. H. S. L. Polak, "India Aspirant."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. C. F. Marsh, "Criticisms of the London County Council Regulations relating to Reinforced Concrete."

FRIDAY, MARCH 1...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor A. G. Green, "The Modern Dye Stuff Industry."

University of London, Slade School of Fine Art, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture VII.)

SATURDAY, MARCH 2...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Problems in Atomic Structure." (Lecture III.)

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, MARCH 1, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 4th, at 4.30 p.m. (Cantor Lecture.) EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." (Lecture III.) HARTLEY WITHERS, Editor of the *Economist*, will preside.

TUESDAY, MARCH 5th, at 4.30 p.m. (Colonial Section.) GEORGE YOUNG, M.V.O., ex-Secretary of Legation, Lisbon, "Portugal as a Colonial Power." SIR OWEN PHILIPPS, K.C.M.G., M.P., will preside.

WEDNESDAY, MARCH 6th, at 4.30 p.m. (Ordinary Meeting.) A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, February 25th; SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., in the chair. Mr. EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, delivered the second lecture of his course on "The Effect of the War on the Economic Condition of the United Kingdom."

The lectures will be published in the *Journal* during the summer recess.

TWELFTH ORDINARY MEETING.

Wednesday afternoon, February 27th; The RIGHT HON. LORD FARINGDON in the chair. A paper on "The Organisation of Commercial Intelligence" was read by SIR WILLIAM H. CLARK, K.C.S.I., C.M.G., Comptroller-General of the Department of Overseas Trade (Development and Intelligence).

The paper and discussion will be published in the *Journal* of March 22nd.

CANTOR LECTURES ON "PROGRESS IN THE METALLURGY OF COPPER."

The Cantor Lectures on "Progress in the Metallurgy of Copper," by Professor H. C. H. Carpenter, M.A., Ph.D., M.Inst.M.M., A.R.S.M., have been reprinted from the *Journal*, and the pamphlet (price one shilling) may be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.

A full list of the Cantor and Howard Lectures which have been published separately, and are still on sale, can also be obtained.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers will be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 13th; ROBERT TOOTILL, M.P., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Chiura, Captain T., Osaka, Japan.
Davies, Rev. John Llanfair, Pembrokeshire.
Dilke, Sir Charles Wentworth, Bt., Brighton.
Frank, Robert, London.
Manville, Edward, M.I.E.E., London.
Moore, Thomas Cartlich, J.P., Stoke-on-Trent.

Nisbet, James Richard, London.

Rait, George L., Surbiton.

Ridge, H. Mackenzie, M.I.M.M., London.

Smith, C. Thomas, Nottingham.

Snell, Sir John Francis Cleverton, M.Inst.C.E., London.

Warnes, Arthur Robert, Hull.

The following candidates were balloted for and duly elected Fellows of the Society :—

Barron, William Alfred, M.Inst.M.M., London.

Bedwell, George Champion, Cambridge.

Brander, James, Bristol.

Britton, William, M.I.Mar.E., Aden.

Challen, Charles Hollis, London.

Elliott, Sir Bignell George, K.B.E., London.

Guild, John, Honolulu, Hawaii.

Hearn, John Edward, Luton.

Hind, John, Kohala, Hawaii.

Lewis, A., Honolulu, Hawaii.

Lidgate, Anthony, Hamakua, Hawaii.

Lucas, Harry, Birmingham.

Quittenton, Charles Henry, Warlingham, Surrey.

Searle, Richard Charles, Leicester.

Sen, Nirmul Chunder, London.

The paper read was—

"ZERO" OF CAPITAL AND LABOUR.

By Lord Leverhulme.

We are living in strenuous times and are making sacrifices of life and treasure on a scale that we are apt to believe is greater than our forefathers, even in their most difficult wars, were ever called upon to endure. But this is obviously only true of dimensions. It is not true of proportions to scale with the resources or wealth of the present British Empire as compared with her former war periods, nor is it true in relation to the resources science has placed at our disposal for our more rapid recuperation from the effects of this war by the exploitation and development of the nascent wealth that nature with lavish hand has stored up for us within our boundaries. To realise the natural strength of the British Empire let us think of it in the words of the poet—

"As some tall cliff that lifts its awful form,
Swells from the vale, and midway leaves the storm,
Though round its heart the rolling clouds are spread,
Eternal sunshine settles on its head."

Our most cruel and deplorable loss in this war is the awful sacrifice of human life, and the irreparable disastrous consequences to civilisation and the progress of the world that must result from so many of the flower of our manhood having been taken from us it would be impossible to overstate. This welter of blood has made the world one huge sob and stifled moan. There is not one single family group in the whole of the peoples of the belligerent nations that has not to mourn some loved dear ones lost, or returned mutilated and torn, blinded or crippled—the wreck and shadow of their former selves. No loving care nor patient toil can restore these or make good to us their loss.

But for the rest the loss can on certain well known and proved established lines be fully recovered, and most speedily of all the money wastage. Many worthy good souls are worrying themselves and the nation as to the undoubted load and enormous burden of national war indebtedness we shall have to carry when this war is over, and are worrying still more as to our ability as a nation to repay these debts. In their alarm, and suffering from an attack of nerves and cold feet, some openly advocate unblushing repudiation of our war debts, and call this by some such specious name as Conscription of Wealth. And in their haste to propound this "cure all" for our ills they cannot even wait until we have won a decisive victory on the battlefield and obtained the unconditional surrender of our enemies, but must needs weaken the national credit by advocating this impossible policy even whilst the necessity for further borrowing still continues.

There are seven pillars of national and individual prosperity and happiness. These are: Justice, truth, labour, capital, science, art, leisure.

The unit of the Empire, as of all democracies, is the home and fireside, and along the lines defined by the seven pillars of prosperity individual nations and the home units have progressed from slavery to fullest liberty. What were the conditions of life in Great Britain in, say, Oliver Cromwell's time, when we experienced our greatest advance towards our present ideal form of Government—a constitutional monarchy? London even then was the largest, the richest, and most populous city in the then known world. Yet it was indescribably dirty, overcrowded, insanitary, badly lighted, and worse drained, and neither health nor life was safe from attacks from disease, pestilence,

or robbers and footpads. The death-rate was over 49 per thousand in ordinary years, and much higher in years of special visitations of plague. In Oliver Cromwell's time close to London were twenty-five square miles of swamps, which to-day are absorbed within the boundaries of the metropolitan area, drained dry and made healthy and built over. In wet weather the streets and roads were impassable, a quagmire of mud in which chariots, waggons and carts sank to their axles. Robbers, footpads, and highwaymen made it dangerous to travel in daylight, and impossible at night to do so without being under convoy of a guard. In the United Kingdom at that time there were thirty-four counties without any, even the most primitive, form of printing-press. The master flogged his apprentice and the husband flogged his wife. The stocks, the ducking-stool, and the whipping-post were national institutions in the most public centres of every town and village. Even a century later we were very little improved in our social life.

What has changed all this to conditions such as exist in the United Kingdom to-day? It has been the discoveries of science and the inventions of mechanics. About the close of the eighteenth century, Watt, Arkwright, Hargreaves, Crompton, Cartwright, and others, invented various of our most important "key" mechanical utilities—such as the steam engine, the spinning jenny, the mule, the power loom, the carding machine, and scores of others. It is said that, as a result of these inventions, twenty-five men and fifty women and boys can produce to-day as much cotton goods as could have been produced by the hand labour of all the men, women and boys that were engaged in the cotton industry in Lancashire in Oliver Cromwell's time.

And what is the condition of London to-day? The population is more than a scorefold what it was then, and it has become the cleanest, most healthy and sanitary, the best lighted and the best drained city, as it is also the largest city, in the world. And all traces of special visitations of plague or pestilence have ceased, and the death-rate is the lowest of any of the largest cities of the world, being no more than 15 per thousand.

And corresponding progress has been made in every city, town, and village in the country, and in the social betterment of the lives of the people, and the British Empire has become the greatest Empire in the world, not by repudiation of the Napoleonic war debts, not by Acts of Parliament, but by the steady maintenance of the beneficent support of the seven pillars of prosperity, and by the labour of employer capitalist, and employee workman. These, as inventors, manufacturers, merchants, explorers and shipowners, have often been handicapped in the march of progress in competition with other nations by stupid Acts of Parliament and ignorant statesmen; but, in rectifying this handicap of progress, let us be careful that we do not commit still greater errors of government in the future. Our best hope for the future is that the whole of the difficulties to be overcome, and of our social betterment to be achieved, shall be fully considered in all their bearings, shall be fully discussed and understood before we enter upon the putting into effect of immature and ill-considered new and experimental policies. We must approach the consideration of the problem with minds free from thoughts founded on prejudice, hatred or temper, free from taint of selfishness or injustice. Above all, we must dismiss from our minds and souls any idea of what, for the want of a better name, we call "class against class" antagonism. In all countries throughout all ages there have been numerous divisions of peoples into so-called "classes," but this good old world, large as it is, has never been big enough to contain more than a division into two great classes—the class that is doing its duty and the class that fails to do its duty. These two great divisions are wide enough and deep enough to include the whole human race, and all other distinctions are purely artificial. But we have got into a slipshod way of thinking of mankind as existing in "classes," and nothing, in the present temper of the world, is more unjust or dangerous. Peer and peasant, employer capitalist and employee workman, have fought side by side in the trenches and laid down their lives side by side on the battlefield in this great war, and as comrades in this war they honour and respect each other as never was possible before; and we have all learned that in about equal proportional numbers there are included, in all the artificial "class" divisions, the industrious and the idle, the intelligent and the stupid, the brave and the cowards, the honest and the cheat, the truthful and the liar, the virtuous and the vicious, the temperate and the drunkard, the strong and the weak, the healthy and the sickly, the thrifty and the spendthrift, and that so long as these opposites of characteristics exist there will always be the rich and the poor. Let us uproot this habit of

thinking of individuals according to certain artificial so-called "classes." Nothing is more unjust and nothing could be more dangerous.

Long before this war began we were experiencing the influence in politics of a new Parliamentary Party whose leaders scorned the beaten tracks of old-school politicians and who called themselves the Labour Party. The employee workmen, through their trades unions, have also become more active, and have rightly and properly—so long as they respect the just rights and liberties of others—organised to improve their position. The betterment of the condition of the employee workers is declared, and I believe truly so, their sole objective and goal, but so far as my knowledge goes the employee workers have not yet unanimously decided upon what might be the best methods for them to adopt to realise betterment and advancement. In short, whilst their aims, ideals and ambitions are clear and definite, their proposed methods for realisation are most indefinite and hazy.

When the dissatisfied colonists in North America won, under the leadership of General Washington, their severance from Great Britain nearly a century and a half ago, they declared as their ideals—and in these the whole English-speaking world agrees to-day—that all men were endowed by God with certain inalienable rights, amongst which were life, liberty and the pursuit of happiness. Washington and his co-founders of the United States believed and trusted that if all men were given an equal opportunity, and if the citizens of a country could frame their own laws and levy their own taxes, the inequalities in wealth that existed in the Mother Country could never exist in the United States. This was the view held in 1776, and the founders of the United States were convinced that the rich and wealthy were rich and wealthy in consequence of some unfairness in the laws of the United Kingdom. But, after nearly a century and a half—in spite of the Declaration of Independence as to equality, in spite of universal manhood suffrage—there are greater inequalities of wealth in the United States to-day than there are or ever were in the United Kingdom, and it is clear that neither Acts of Congress nor the Constitution of the United States have been able to make all men equal in wealth any more than in health, weight or stature, brains or muscle, piety or morals, character or worth. But this inequality of wealth, although infinitely greater in 1916 than in 1776, at which time, as often is the case to-day, it was thought to be the cause of all the poverty of the poor, has been proved to have relieved the extremes of poverty and wretchedness, to have greatly raised the average of comfort and betterment, and to have resulted also in actually a better distribution and more plentiful supply of wealth amongst the employee workmen. The United States has produced millionaires in greater number and of greater individual wealth than ever the United Kingdom produced, and yet the employee workman in that country receives the highest rate of wages known in the world. In 1776 it was believed that in the United Kingdom the Government had somehow interfered with some great principle underlying all social well-being, and that in the United States, under the Constitution adopted in the Declaration of Independence, wealth would be more equally distributed and poverty would cease. But the result has clearly proved that so long as some men are stronger, or more healthy, or more intelligent, or more industrious, or more virtuous, or more self-denying, or more thrifty than others, that there will be inequalities of wealth, and that the employer capitalist was not responsible for this, nor was the employee workman to blame, and that if either changed places with the other by Act of Parliament, that change over would constitute no remedy for acknowledged inequalities nor be a stimulus to social betterment for all. Employer capitalists, in acquiring their wealth by hard work of brain and energy of body, have benefited not only themselves and their families, but have, even if unwittingly, conduced to the betterment of the employee workman and also to the progress of the whole of the industries of the United Kingdom.

And now I venture to assert that, notwithstanding that all the above circumstances are inevitable and normal and natural, still no employer capitalist with a true feeling of brotherhood can be quite happy in the fullest sense in the enjoyment of wealth—the product of his own hard work, intelligence, self-denial and thrift, every penny earned without committing injury to any man, and the acquisition of which has resulted in enormous benefits to his employee workmen — without feeling a sense of dissatisfaction with present industrial conditions and a strong desire to improve them so that the employee workman may be raised to a much higher level in social well-being.

But this idea cannot be achieved by an Act

of Parliament for the conscription or confiscation of wealth.

The men and women of British stock who crossed the Atlantic and founded the United States did not state in their Declaration of Independence that all wealth must be confiscated to the State. What they did declare was that man was endowed by God with certain inalienable rights of life, liberty, and the pursuit of happiness. Do these rights mean that Government should conscript or confiscate the fruits of the industry of one man who had led a thrifty, wholesome, industrious life, in order that Government might use the same for the benefit of men who had lived lives of exactly the opposite type? That was certainly not what the citizens of 1776 ever intended. What was meant was that every citizen had the fullest liberty to live his own life and to make his own livelihood in his own way so long as that was honest and true, and that he was entitled to the full enjoyment of the product of his labour, whether of muscle or brain, and for the pursuit of his own happiness—also within honest and true limits—in his own way.

And what was meant by liberty? One of the best definitions of liberty has been stated by—if I remember correctly—a French Convention in the following words—

"The liberty of one citizen ceases only where it encroaches on the liberty of another citizen."

And as to the pursuit of happiness, John Bright has given us one of the best definitions of happiness—

"Happiness consists in a congenial occupation with a sense of progress."

In addition, this Declaration of Independence laid down the axiom that Governments were instituted to preserve these rights to the people, and that the people themselves were the source of all the power that Governments possessed. The force that has created the United States has not been Congress, nor was the British Empire built up by Parliament. There would have been no United States and no British Empire without the labour and toil and sweat of the people of the two nations. Governments create no wealth as such, and possess no money but what they receive from the taxation of the people. All Governments are paupers, and only exist in free democratic nations by the consent of the governed. All Governments being paupers they have only two means for raising money—by taxation and by borrowing. In times of war, or for great public undertakings such as waterworks, or municipal developments such as docks, etc., borrowing has had to be resorted to in the past years as in the present years, and will have to be resorted to in the years to come when this war is over. The power and ability of a Government to borrow and the rate of interest to be paid depend entirely on the credit of the Government concerned, and on the assured belief of the lenders in the borrower's ability and good faith for the due payment of interest and the repayment of the debt. Our British Imperial and Colonial Governments and our municipalities have hitherto enjoyed the power to borrow all their requirements at the world's lowest rate of interest. This advantageous position is entirely due to public confidence in the honour, honesty and good faith of our Governments. If we once shake confidence in either our ability or our willingness to repay our indebtedness, then our credit and power to borrow is either seriously damaged or may be hopelessly destroyed. And with this destruction of credit and confidence would come equally the ruin of our industries, and unemployment and hunger would be our chronic condition. If we, as British citizens, cannot realise these truths then we are in greater peril than if the Prussians had landed on our shores and were marching through an undefended country on defenceless cities and towns. The British Empire might recover in time from defeat in war, but the British Empire never could recover from its own default to repay its war loan indebtedness. The credit and confidence enjoyed by the British Empire is the one and only foundation on which stand four-square to all attempts to overthrow them the prosperity and stability of British industries, and ability to provide full employment at full wages for the British workman. The repudiation of debt, or the so-called conscription of wealth, would be an assassin blow at the very heart of the British Empire.

But even if it were a practical and honest policy there would be two questions still that would arise and require to be answered—how could such conscription be accomplished, and what would it yield? The suggestion is that we conscript sufficient of the wealth of the country on some graduated scale to enable us to repay at least £4,000,000,000 of war loan indebtedness. How would our Government collect this £4,000,000,000 and convert it into cash — for it is obviously only

as cash that wealth could be used for the repayment of war loans? At present this wealth exists in the form of furniture, pictures, china, works of art, houses, land, workshops, factories, machinery, ships, horses, cattle, sheep, and the thousands of other forms of wealth, including debentures, shares, mortgages in public railways, industrial companies, municipal and dock loans, Government war loans, deposits in banks and building societies. And this wealth includes the savings of the frugal father for his widow and children equally with those of the millionaire. We know the depreciation that takes place when trustees are forced to sell some portions of an estate in order to pay death duties. But only some £30,000,000 a year are paid in death duties, and much of this we know has been received by the trustees in hard cash from banks and insurance companies. It is only a cautious estimate to assume that not more than two-thirds had to be raised by forced sales—say £20,000,000 a year. But to realise even this modest sum each year has tended to depress the market value of securities. So that it is clear that no market could be found for £4,000,000,000 of conscripted wealth at what I may call par value, and as practically everyone with wealth would be a seller, and there would be almost no British buyers, it is only reasonable to say that the £4,000,000,000 of conscripted wealth would not realise in cash as much as £400,000,000. It would be almost valueless and unsaleable, and therefore not available for the purpose intended of repaying war loans. The confiscation of wealth would carry the country, ice-bound, below zero. Left to fructify in the pockets of its owners, it would produce its yield in income tax and death duties to the State, and in employment for employee workmen, not only of the then existing factories and workshops, but still more important, of extensions and additions thereto, and for the provision of capital for working and building the same, to be obtained on the credit of the security available. But conscript 10 per cent. or 20 per cent. of the wealth of the country, and not only would the conscripted portion be unsaleable, but the balance would be depreciated as security for credit to finance our industries to the lowest level of the conscripted portion. This would be like cutting out the roots of the tree to anticipate the next year's crop of fruit.

But this cutting out of roots is certainly not what wise men would do. They would guard the roots, fertilise them, prune the dead roots, support the limbs and branches, protect from frost the blossoms, and finally reap an abundant harvest—growing larger in quantity and better in quality each year of patient care and cultivation. Therefore our course for repayment of war loan lies in cultivating our industries and fertilising them—root pruning by death duties, and collecting the harvest by means of income tax graduated so that all citizens with incomes of £80 a year and over contribute according to their means. In no other way can we realise so large a cash income to pay off our war loans so speedily and quickly, maintain British shipping and industries, find ever-increasing employment for British labour, and maintain British credit and the pre-eminent present position of our world-wide British Empire.

It may be asked how steeply can income tax and death duties be graduated; the answer can only be that if our needs require them, then the only limit can be that point at which they yield the largest return to the State with the least injury to our industries. If income tax at 5*s*. in the £, and death duties at 20 per cent., yield the largest return to the State with least injury to our industries, and if income tax at 10*s*. in the £ and death duties at 50 per cent. would yield actually less to the State, and would also threaten our industries with ruin, then the lower figure without risk to our industries would have been proved to be the only practicable rate. In other words, at the high rates you would be killing the tree that bears the golden fruit.

Every farmer and gardener knows that such a hint as decreased yield from nature as to the limits of cropping, if disregarded, sours the land and the plants, with ruinous results. The reduced yield from the higher rate would also prove that trade and commerce, house-building, ship-building, and our manufactures were suffering from being denuded of capital by excessive taxation, and that unemployment would soon be stalking, with famine and sickness, through our land. And we should find that a just, fair, and reasonable scale of graduated taxation will not only yield the largest amount of cash to the State, but that the remainder, left to fructify in the pockets of its producers, will act as a stimulus to the production of ever larger and larger taxable incomes, and to the employment of an ever-increasing number of employee workmen by employer capitalists to the expansion of British

shipping trade and commerce, and to the maintenance of our present pre-eminent position amongst the nations of the world. So graduated income tax has its zero point.

"All that freedom's highest aims can reach
Is but to lay proportion'd loads on each.
Hence, should one order disproportion'd grow,
Its double weight must ruin all below."

No, there is only this one way available to enable us to repay our war loans, to re-establish our mercantile marine, our trade, commerce and manufactures after this welter of a world war, and that is to stimulate the production of wealth and to tax the annual income to the limits of utmost yield, but always so that the producers of wealth are encouraged, stimulated, and are left with the necessary means for the production of more wealth. This production of increased wealth will demand and necessitate that every adult man and woman of all classes shall, up to the limit of his abilities and capacities, work hard and strenuously for its production. But human strength has its economic zero point also. If in the production of this wealth either the employer capitalist or the employee workman is over-fatigued by working a longer number of hours than the limitations demanded by health and strength, then the result can only be disastrous to the production of wealth. But if all adults, of both sexes and of all classes, peer and peasant, employee capitalist and employee workman, work each a reasonable number of hours per day, then, without over-fatigue of any, we can produce a wealth of products sufficient for our own home markets and wants and for overseas exportation, far in excess of anything we have ever previously accomplished. The exact number of hours that will produce overstrain and fatigue, with resulting lower production, will obviously vary with the nature of the occupation and with the conditions under which the work is performed. On the farm, for instance, and on board ships, surrounded by green fields or green ocean and fresh air, the hours worked may presumably be longer than would be possible in factories, mines, workshops, foundries, offices, or stores, where perfect ventilation is never quite attainable, and where the occupation is more or less monotonous. But in every kind of work and employment there must be some limit to human strength and endurance, and experience has taught us that between eight hours a day as a maximum and six hours a day as a minimum, the safety point may most probably be found to rest. These hours of daily toil are what may be called the income-making period—the remaining hours are available not only for sleep, eating, recreation and leisure, but also for education and public service and all the refinements of life. St. Paul has told us that he "laboured with his hands that he might be chargeable to no man," and we know that he was by trade a tentmaker. The hours of labour for tentmakers were, I am told, at that time from 5.0 a.m. to 11.0 a.m., that is six hour per day, and the remaining hours St. Paul devoted to his life's work—service to his fellow man. Let us organise our time better. At present all our time is devoted to gathering income for maintenance as if we were so many cows and sheep, all of whose time we know is devoted to the work of maintenance. Our factories, foundries, mines, workshops, stores, offices and farms throughout the British Empire are full of men or women with ideals and ideas for utilities and inventions, and who, in addition to their capacity for the work of income-earning for maintenance and support of themselves and families, are capable of, and keen for, work of enormous social value to their fellows and the Empire. What a wealth of inventive genius and ideas have we there running actually to waste through our bad organisation of their hours of work, and their subjection to overstrain and fatigue in the performance of the daily round of routine duties for income producing. Under our present system each day has to be fully occupied in reaching the fatigue limit in work for income for maintenance, with the result that our machinery is underworked and our workers are overwrought, giving us less wealth produced at greater cost than need be the case. Thought and ideas for new inventions and processes require intelligence, alertness and leisure—all impossible under conditions of over-fatigue during long hours of laborious toil. Then see how the wage and salary fund is impoverished. We can only work our machinery and mechanical utilities longer hours by working human beings fewer hours. We have already exceeded the limit of human endurance from school age to dotage. But if we reorganise our factories so that by working a number of change shifts of employee workers six hours each shift we can run our machinery twelve, eighteen, or twenty-four hours each working day. The wages paid at present for longer hours would require to be paid for the fewer hours, and in order to do this the total cost of production, which is partly

interest, depreciation and repairs for machinery —all of which would be little if at all increased by the additional hours worked—would on an increase of from 50 per cent. to 200 per cent. in the output give us lower costs, out of which wages could be increased and selling price to customers reduced. And believe me it is impossible to lay too strong emphasis on this crux of the whole proposal, which is the one and only basis which would make reduced hours and higher wages possible—namely, reduced final costs and lower selling prices for the consumer, with more wages to the worker and fewer hours of toil. The employer capitalist could, of course, work with a lower percentage of profit and yet realise on his increased production a larger income to meet the demands made upon him for higher graduation in rates of income tax.

And now let me say a word on the value of a better organisation of time devoted to income-earning in its effect on education of brain, body, and mind, and the power it would give the State for training citizens for military service. In all change shifts the shift workers who one week worked in the morning would the next week work in the afternoon, so that there would be for everyone the morning or afternoon free each week alternately. From fourteen to eighteen years of age there would be for boys and girls two hours morning or afternoon each day required by the State to be devoted to higher grade education and physical training. From eighteen to twenty-four the State would require that these two hours be devoted each day to technical and higher education such as is provided to-day only in our universities, and for physical training, and from twenty-four to thirty years of age the State would require that these two hours each day be devoted to military training and preparation for National Service. After thirty years of age the citizen would have completed his period of compulsory attendance under State regulations, and would be fully equipped by education and training for all the duties of citizenship; and might reasonably be trusted to make, as did St. Paul, but in his own way, his own voluntary contribution to social advancement and betterment.

But in addition to a better organisation of time in our industries, we require to advance still further in the direction of a more logical basis in the relationship between the employer capitalist and the employee worker. There must be some consideration given to the division between these two of the profit resulting from the joint labour of both. The wages system alone is not sufficient, but the wages system must of necessity remain the basis for the employee worker. It is a system that has stood the test of time; it is convenient; it is logical and practicable. Under the wages system the employee worker practically says to the employer capitalist: "I cannot undertake to bear any of the risks of this business. I must receive a weekly or monthly income, regularly, upon which I can absolutely rely and depend for my household expenses: therefore, if I engage with yourself, we must mutually first agree on a sum which you shall pay me as wages or salary in exchange for my services. If, after paying this sum of money to myself, and also after your payment of all other expenses of the business, there is a profit remaining, I agree that that profit shall be yours. If there is a loss you must make that loss good yourself alone, even to the extent of bringing ruin and disaster upon yourself and your family. I cannot share with you your losses, and I agree to make no claim upon you to share in your profits." This, I repeat, is the logic of the present wages system, and it is perfectly sound and just in its basis and principles.

The admission to co-partnership is not a right that the employee worker can of necessity claim. It is obvious that there must always be the right with each of us to choose our partners by mutual consent, if the true co-partnership spirit is to be maintained. The employer capitalist can choose his partners, and does choose them from those who can give him the best help and can best strengthen his business, either by contribution of capital or assistance in the management of the business; and in making this selection of partners every care and effort is directed to avoid entering into a partnership that may prove undesirable in practice. The happiest and most successful relationships in business life have been realised under the partnership system, and it is equally true that occasionally, from various causes unforeseen at the time, private partnerships have proved disastrous, both from the point of view of prosperity of the business, or the happiness of the partners. But the intention has always been the same—namely, to help and strengthen the business and to share the responsibility and risks of the business between the partners. I am confident that, viewed in this light and not as a profit-sharing device, which in my opinion would be wrong,

co-partnership relations with the employee worker would be an added source of strength to any business to which co-partnership could be applied, and would increase the prosperity and happiness of both the employer capitalist and the employee worker. The application of the principles of co-partnership between these two is just as sound and practical a business arrangement as between any body of partners, and one that might just as wisely be entered upon.

Under the operation of our modern industrial developments, capital is generally raised from a body of shareholders, in the form of ordinary shares. These ordinary shareholders divide amongst themselves the total remaining profits of the business after payment of all claims for salaries, wages, interest and other prior charges. The ordinary shareholders of a company are practically the partners who control the destiny of the company by their vote, but it is very rare for any of them to be engaged actively in the business as employee workers. It can never be a source of strength to the business that the whole of the surplus profits, after paying a reasonable and proper rate of interest, should be entirely devoted to dividends to ordinary shareholders. I am convinced that the best interests of the ordinary shareholders would be better served, both in regard to the rate per cent. of their dividends and the security of their capital, if the surplus profits could be divided, under some scheme of co-partnership, between the employee workers and the ordinary shareholders of the business.

It is not in the best interests of the success of any business, nor of the progress and development of British industries as a whole, that the entire surplus profits should take only one channel, and that channel a direction away from those most interested in the business, and upon whom must depend the continued success of the business. It would not be right to view this question of co-partnership from any benevolent point of view. There can be no philanthropy in business. But the cultivation of a spirit of co-partnership, and of a keen interest in the firm in which the employee workers are engaged, is not philanthropy but sound policy. The whole of the goodwill of any business, which goodwill is often of greater value than the actual bricks and mortar, plant and machinery, depends on mutual confidence. The employer capitalist and ordinary shareholders to-day view the employee worker solely as a liability. Employees are not liabilities, but the most valuable of all the assets of any business.

An objection often raised to profit-sharing, and, I think, rightly raised, is that there can be no loss-sharing. Under the system of co-partnership, loss-sharing can be linked up with participation in profits. After all, what are the losses of capital for the employer capitalist? His losses of capital are that certain shares that he holds, by purchase or original application and payment, have become valueless because they have ceased to have earning capacity. One has often heard of shares in some company that has entirely lost its earning capacity, being only fit to make into spills to light cigarettes with — their capital value has become *nil*. Equally, the co-partnership certificates issued under a scheme of co-partnership to the employee workers would be only fit to make into cigarette lighters, and absolutely valueless, if the power of the business to earn profits had ceased, notwithstanding all the efforts of employer capitalist and employee co-partner.

It is quite obvious that, under a system of co-partnership, whereby an employee worker receives each year an allotment of co-partnership certificates in proportion to the amount of his salary or wages, and the length and value of his services—which co-partnership certificates are, during the co-partner's connection with the firm, entitled to dividends in proportion to the dividends paid to the ordinary shareholders—the co-partner would see the number of co-partnership certificates growing each year. He would experience the fact and would realise the cause why dividends some years were higher than others, and why some years, from unavoidable causes, dividends might fail to be earned or paid. He would realise the direct connection between profits and all the problems that the management have to solve in a business, and in this way the employer capitalist would have secured a partner whose brain would be at work as well as his hands, in effecting economies and avoiding waste in the business, and in making suggestions for the improvement of processes and improvement in the organisation of the time of himself and comrades, so that profits might be increased and higher dividends be paid.

I claim that the employer capitalist is not reasonable if he expects, in exchange for wages, any more than the performances of the services which he has contracted for. But, in addition to services that could be rendered on a wages

system, there is that constant thought and care, outside business hours just as during business hours, for the good of the business which the employer capitalist himself does constantly manifest, otherwise his capital would be in danger and his dividends might never materialise.

Under a system of co-partnership the employer capitalist would have all his employee workers, who had been with him a certain number of years, as co-partners now realising that their interest in the business, equally with that of the employer capitalist, ran along the lines of increased output and of cheap cost of production, and there would come what I may call "team-work," which in the Army is, as you know, called *esprit de corps*, which results in a spirit of comradeship in overcoming all obstacles, and which is specially manifested in times of difficulty and danger.

Had time permitted I would have liked to have amplified many other aspects of the advantages to our industries that would be derived from co-partnership, but I have already transgressed on the limits of your patience. I may just say that to anyone specially interested in co-partnership I should be very glad to send copies of many addresses I have given on this subject which deal much more fully and completely with this great subject than is possible in the time available on this occasion.

But whilst my endeavours have been to record the views I hold, and hold very strongly and sincerely, that Governments of themselves cannot create wealth, that the power of Governments to confiscate or tax wealth is strictly limited within the range of such rates as will produce the largest cash income for the service of the State without danger of check or hindrance to the production of wealth and opportunities for employment; to show that we shall require the labour of all adults of both sexes and of all classes from peer to peasant to repay our war indebtedness and to provide products for home consumption and for exportation overseas, I have endeavoured to show that work also has its limitations of profitable production, and that to overstrain employee worker or employer capitalist is not to produce the best results from either. I hold equally strongly that Governments can render such services of the State as will furnish opportunities and facilities, encouragement and stimulus, for the creation of wealth by the citizens who have entrusted the State with powers of government. The State should and could make concentrated and well-considered efforts to provide every facility for honourable enterprise and honest industry. Our mercantile marine must be protected at sea and provided with ample harbour and dock facilities in the ports of the Empire. Shipowners, manufacturers and merchants must be encouraged and helped by an efficient Consular and Foreign Office service, so that our ships may sail over every sea and our flag be flying in every port. The State can improve our banking system by encouraging and stimulating our bankers to render increased credit facilities for the manufactures, trade, commerce and mercantile marine of the Empire. In our Crown Colonies our Government can construct roads and bridges, build railways, open up new and rich territories of virgin forests, fertile soils and rich minerals, to developers, planters, and traders on terms that would encourage and justify private enterprise in the investment therein of capital. The State can improve the sanitation and healthiness of our villages, towns and cities at home and in the Colonies, and so not only lengthen human life but reduce the toll on productiveness caused by ill-health. Government can protect child-life and see to its welfare, and can improve our educational system so that we get the utmost in the finished product for the many millions we spend upon education, so that the child of the employee workman can have the opportunity of becoming as well educated as the child of the employer capitalist. Government can remove all incidence of taxation and rating, local or Imperial, from improvements on land such as houses and buildings of all kinds, and from machinery, and provide that all such taxation and rating shall, in future, be provided from local and Imperial income tax source, and on site values. All obstacles, in short, for the development of the resources of the Empire at home and overseas must be removed, and every facility, encouragement and security be given to stimulate the production of wealth. Otherwise, what right or title have we members of the British race at home and overseas in the possession and enjoyment of a world-wide Empire on which it is our boast that the sun never sets? If our Government is not sufficiently far-sighted or so wise as to foster facility and encourage great industries capable of producing enormous surplus wealth by the enterprise of her citizens within this world-wide Empire, which would not only find employment for all, but provide a basis for taxation of incomes that would enable us to

repay our war debts, then the British Empire is suffering from the palsy of old age and we shall soon cease to exist as a world Power. Empires rise and fall as they are well and wisely or badly and stupidly governed. Under wise government they become rich and powerful, their ships sail over every sea and carry the national flag into every port; their colonies cover whole continents; their peoples are happy and contented, well housed and well fed, and not overwrought to maintain themselves in comfort in homes where, with wife and children, life lengthens and joy deepens; their rulers and statesmen are honoured and respected by surrounding nations, who can view without bitter feelings of wrong to themselves a world-wide Empire wisely governed with every facility and opportunity, and where welcome is given to all right-minded citizens of all right-minded nations. Nothing can be better for the progress of civilisation and the well-being of the whole world than such a government of such an Empire. And it must with equal truth be stated that there can be no more pitiable sight in the whole world than such an Empire held and possessed by a nation that has neither the vision nor the intelligence to develop wisely or govern justly. "Where no vision is the people perish."

DISCUSSION.

THE CHAIRMAN (Mr. Robert Tootill, M.P.), in opening the discussion, said he thought all present would agree that the paper was the finest exposition of the subject that they had ever heard or read. Speaking as one who had been more or less in the front-line trenches of the labour movement for forty-six years, he considered that the paper ought to be printed in pamphlet form and distributed broadcast amongst the workers of this country. It was very easy to talk about conscription of wealth. The man in the street and the man in the workshop naturally thought that the wealthy classes were not doing their fair share towards the maintenance of the war, and that they by their labour were contributing more than the wealthy classes. Conscription of wealth appeared to them to be a plausible scheme, but the difficulties of applying it without ultimate injury to themselves were very serious indeed. A great deal of ignorance existed on the subject at the present time, and the paper had shown what would be the real results of the conscription of wealth which was suggested by many of the Socialist and Labour leaders of the country. If it was to be carried out equitably it must apply all round, and there must be no partial and discriminating legislation. There was said to be one law for the rich and another for the poor, but that was only true to the extent that the rich were able to pay better equipped and more intelligent counsel to plead their cause. People had the power within themselves to make the best of their physical and mental resources. They were all human beings and to that extent started equal, and their environment, training, opportunities and privileges made most of the difference. He was glad to hear the author describe workmen and employers as comrades, and point out that there was need for greater dissemination of mutual confidence between them. His (the Chairman's) own policy for removing the doubts and suspicions that at present existed between them was that there should be selected from the various departments of firms the most intelligent and capable men, who should be taken into the board-room and into the office, not to override or to dictate, but to discuss with the employers the difficulties of the various propositions put forward. Then those workmen should go back to their comrades in the workshop and explain the difficulties to them. He might mention that the Minister of Labour had asked to be furnished with a copy of the paper, and that he had told him he would find it extremely useful to study.

MR. LEWIS HASLAM, M.P., agreed with the Chairman that the paper ought to be distributed widely throughout the country. It should be read by employers and employed, and also by the heads of the Government. The development of character was of the utmost importance at the present time; everyone wished that people in the future should be honest citizens, and that goodwill should take the place of suspicion and distrust. Ignorance was the cause of all the trouble that existed at present between class and class, and until it was dispelled there would always be that suspicion which created distrust and was the enemy of progress. There was much misunderstanding, for instance, on the question of the proportion paid by the wealthy classes towards the cost of the war. He had worked it out the other day, and had come to the conclusion that four-fifths of the money now paid into the Exchequer came from the income-tax paying classes, who now had a spending power of not more than one-third of what they had in pre-war times. If employers and workmen put their heads together, and worked loyally together, the wealth of the nation could easily be increased by 50 per cent., or £1,200,000,000 a year. Lord Leverhulme had not touched on the question of improving our transport system, but personally he thought there ought to be some means of amalgamating the various systems, so that the best use might be made of the canals and railways of this country, and the present competition between them be avoided.

SIR SWIRE SMITH, M.P., said the paper had opened up a vision of what the country could do, even under the present difficult circumstances. About thirty years ago, after the inquiry of the

Royal Commission on Technical Instruction, of which he was a member, and which began its work in 1881, he was invited by the Society of Arts to read a paper on the Technical Education Bill. Two or three years after he read that paper the present Technical Instruction Act was passed, and he believed that technical instruction had saved the industries of this country. Before that Act was passed this country was behind its competitors in every direction, and our educational system was deplorable. Mr. Forster's Education Act had only been adopted by a proportion of the country, and there was not a single well-equipped technical school in the length and breadth of the land. Since then a great improvement had taken place, but even now we were surpassed by other countries in many subjects. We were still behind some countries in everything connected with science, for instance, because we had not given the attention to the subject which we ought to have given. A great improvement would take place if this country followed the advice given by the author in his paper, if it determined that Mr. Fisher's Education Bill should be passed, and if it insisted that all boys and girls between the ages of fourteen and eighteen should attend school for a certain number of hours a week, devoting time to the study of citizenship and all those things which they required for their physical health and mental and moral development, and that after the age of eighteen they should continue to give a portion of their time to the higher branches of technical instruction in art as well as in science.

Mr. Robert Applegarth, speaking as one who had travelled abroad a great deal and had studied the educational and industrial systems of other countries, thought that the question of education was of far more importance than any of the other subjects dealt with in the paper. The State should be made to recognise the fact that it must feed, clothe, educate and train all its children. If all children were given equal opportunities and a proper education, people would begin to find that the working-classes would not need lecturing. He was convinced that if the people of this country were given the education to which they were entitled they would then settle the whole of the details put forward by the author, and would produce for use and not for profit.

On the motion of the Chairman, a vote of thanks was accorded to the author for his interesing and useful paper.

Lord Leverhulme, in responding, desired to accord the thanks of the meeting to the Chairman for presiding. He thought the Chairman had struck the right note when he emphasised the necessity of removing the suspicion and distrust that at present existed between employers and employed.

The meeting then terminated.

OBITUARY.

Earl Brassey, G.C.B.—The Society has lost an old and much valued Fellow by the death of Earl Brassey, which took place at his residence in Park Lane on February 23rd.

Thomas Brassey was born in 1836, and was educated at Rugby and University College, Oxford. He entered Parliament as Liberal member for Liverpool in 1865. From 1868 to 1886 he represented Hastings. In 1880 he joined Mr. Gladstone's Government as Civil Lord, and was afterwards Secretary, to the Admiralty. He was created a K.C.B. in 1881. In 1886, after the defeat of the first Home Rule Bill, he withdrew from the constituency of Hastings and offered himself as a Gladstonian candidate for one of the divisions of Liverpool, but he was defeated. On the resignation of the Government he was raised to the peerage. In 1895 he was appointed Governor of Victoria. In 1906 he became a G.C.B. From 1908 to 1913 he was Lord Warden of the Cinque Ports, and he received an earldom in 1911.

It is hardly possible to think of Lord Brassey without associating him with his famous yacht, the "Sunbeam," in which he travelled over 400,000 knots, and which, after her owner had made his final voyage in her to India, was in 1916 handed over to the Indian Government for permanent use as a hospital ship.

Lord Brassey's connection with the Royal Society of Arts was of very long standing. He himself became a member in 1862, and six years earlier his father, Thomas Brassey, a well-known contractor for public works, who constructed railways in many parts of the world, had been elected. Lord Brassey served on the Council, with few breaks, from 1871 to 1882, and again from 1913 to 1915. He was also a member of the Colonial Section Committee for many years, and remained on it up to the time of his death. He was frequently present at the Society's meetings; he presided on several occasions, and often took part in the discussions.

GENERAL NOTES.

The German Mercantile Marine.—Some of the largest German shipping firms, according to *Engineering*, have recently placed orders with German yards for over 150,000 tons. This is, no doubt, the first effect of the new German merchant navy aid measure, and the fact of the first instalment of 300,000,000 marks having been asked for. Another step for the financial assistance of German shipping is the impending creation of a ships' loan bank, with an initial capital of 10,000,000 marks, subscribed by some of the leading banks. The new bank is not intended to confine its activities to sea-going vessels, but will also assist river traffic. The Oder yard in Stettin is again increasing its capital so as to raise it to 4,000,000 marks.

MINERALS IN SIAM.—Mining engineers who have recently visited the Southern Siamese Malay States have come to the conclusion that it is one of the richest mineral areas in the world. In addition to wolfram, rich deposits of tin alluvium are found in the valleys and gullies of all the hills in which wolfram has been found, says *Eastern Engineering*. In most of the hills the number of wolfram lodes already located exceeds ten, and in all of them tin has also been discovered. Plenty of water with sufficient head is said to be available for washing out the tin in the rainy season, and there are possibilities for storing water in reservoirs for the dry season. There is a waterfall close by with sufficient head to develop electric power for working a large number of mines. In Northern Siam mining areas adjoining the new railway extension have been opened, and there antimony and lead are worked, the lead being mixed with zinc and containing some silver.

GAS TRACTION.—Evidence has been laid before the Gas Traction Committee by manufacturers of flexible gas containers, according to which about 4,500 commercial motor vehicles have been equipped to use coal gas instead of petrol. Orders for an additional 2,500 flexible containers, all for business vehicles, are in hand for completion during the next few months. The evidence shows that under 4 per cent. of the total deliveries to date have been to owners of private motor cars, that no further orders in this category are being taken, and that practically the whole of the manufacturing processes are being carried out by woman labour. The estimated saving of petrol is already at the rate of, approximately, 3,000,000 gallons a year.—*Railway News*.

OSTRICH LEATHER.—Last year a tanned ostrich skin was sent to the South Africa Trades Commissioner, who obtained the following report from one of the most expert fancy leather tanners in the United Kingdom: "The most likely purpose we could suggest for such would be dressing-case work. Its unusual appearance on the exterior of travelling bags would attract a class of buyers who like their luggage to have a *distingué* appearance, and willingly pay the extra tips to porters who respectfully salute it. Black would hardly be a suitable colour. A suitable shade of green would be better for the purpose indicated, or some of the art shades or saddle brown, such as are sent to London for less aggressive purchasers. Furniture covering is another use to which they could be put. The small pieces could then be used for pocket-books, tobacco pouches, etc. In all this type of trade it is just a question of introducing a fashion. They advisably should be tanned in this country tastefully with that objective in view. Meantime the War Office frowns on any utilisation of skilled labour for other than military leathers, and while serious development might be begun, it could only be completed on scale after the war is over."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

MARCH 6.—A. H. PATERSON, Secretary, National Alliance of Employers and Employed, "The Foundation of Industrial Peace." The RIGHT HON. FREDERICK HUTH JACKSON will preside.

MARCH 13.—PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres and other Flemish Cities before and since the War." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] The ARCHBISHOP OF CANTERBURY will preside.

MARCH 20.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

APRIL 10.—W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry." PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., will preside.

APRIL 17.—PERCY SHUTTLEWOOD, Ministry of Food, "The Food Situation in Germany."

APRIL 24.—MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons."

MAY 1.—GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

MAY 8.—JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

MARCH 14.—WILLIAM FOSTER, C.I.E., "English Commerce with India, 1608-1658."

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India."

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Colonial Section.

Tuesday afternoons, at 4.30 p.m.:—

March 5. — George Young, M.V.O., ex-Secretary of Legation, Lisbon, "Portugal as a Colonial Power." Sir Owen Philipps, K.C.M.G., M.P., will preside.

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

Cantor Lectures.

Monday afternoons, at 4.30 p.m. (unless otherwise announced):—

Edgar Crammond, Secretary of the Liverpool Stock Exchange, "The Effect of the War on the Economic Condition of the United Kingdom." Three Lectures.

Syllabus.

Lecture III.—March 4.—*The Real Cost of the War and the Problem of Economic Reconstruction.* War expenditure of the British Government —War debt — Pensions — Education — Imperial Revenue and expenditure — Excess profits duty —Levy on capital—National debt after the war —Economic reconstruction — Problems of demobilisation—Commercial relations of the United Kingdom with the Empire and our Allies—Interaction of International trade and finance on the economic life of the United Kingdom — The investment of capital abroad.

J. Young, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

Cobb Lectures.

Professor Henry R. Procter, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 4 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. E. Crammond, "The Effect of the War on the Economic Condition of the United Kingdom." (Lecture III.)

Victoria Institute, Central-buildings, Westminster, S.W., 4.30 p.m. Rev. H. J. R. Marston, "The Reserved Rights of God."

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Professor E. Leflac, "Intensive Agriculture and Catch-cropping in Belgium."

Tuesday, March 5...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Mr. G. Young, "Portugal as a Colonial Power."

Röntgen Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8.15 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir R. T. Glazebrook, "The National Physical Laboratory." (Lecture II.)

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Civil Engineers, Institution of, Great George-street, S.W., 8 p.m. Mr. A. Meade, "Modern Developments in Gasworks Construction and Practice."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Mr. R. I. Pocock, "On the External Characters of the Lemurs and *Tarsius*." 2. Sir George F. Hampson, "A Classification of the *Pyralidæ*, Subfamily *Hypsotropinæ*."

Wednesday, March 6 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. A. H. Paterson, "The Foundation of Industrial Peace."

Geological Society, Burlington House, W., 8 p.m.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor S. D. Adshead, "Town-planning in its relation to Public Health."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m.

Thursday, March 7...Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Professor E. B. Poulton, (*a*) "The Mimetic and Mendelian Relationships of the 'White Admirals' of North America"; (*b*) "A new Mimetic form of *Pseudacræa poggei* (Dewitz) from ex-German East Africa, with other African mimics of *Danaida chrysippus* (Linn.)." 2. Lord Rothschild, "Mimetic species of the African Nymphaline genus *Pseudacræa* and Lycænid genus *Mimacræa*, together with their Acræine and Danaidine models and some of their co-mimics."

Chemical Society, Burlington House, W., 8.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Alexander Mackenzie, "War Music: Past and Present." (Lecture I.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. R. A. Malby, "Photographic Records of a Miniature Alpine Garden."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. E. B. Wedmore, "The Control of Large Amounts of Power."

Southern District Association of Gas Engineers and Managers, at the Royal Society of Arts, John-street, Adelphi, W.C., 2 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. 1. Mr. H. R. Edmands, "The Application of Charcoal to the Precipitation of Gold from its Solution in Cyanide." 2. Mr. W. R. Schoeller, "Blast Furnace Smelting of Stibnite, with considerations on the Metallurgy of Antimony." 3. Mr. B. Angwin, "A Responsive Shaft Signal Device."

Friday, March 8...Royal Institution, Albemarle-street, W., 5.30 p.m. Professor E. H. Barton, "Vibrations: Mechanical, Musical and Electrical."

Astronomical Society, Burlington House, W., 5 p.m.

University of London, Slade School of Fine Art, University College, Gower-street, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture VIII.)

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Saturday, March 9...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Problems in Atomic Structure." (Lecture IV.)

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Royal Society of Arts

CANTOR LECTURES.

A full list of the Cantor Lectures which have been reprinted from the **Journal** and published separately may be obtained on application to

THE SECRETARY, John Street, Adelphi, London, W.C.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

HOWARD AND OTHER LECTURES.

Heavy Oil Engines. Four Lectures. By Captain H. RIALL SANKEY, R.E., M.Inst.C.E. (1912.) Price 1*s.*

Aeronautics. Three Lectures. By Prof. J. E. PETAVEL, D.Sc., F.R.S. (1913.) Price 1*s.*

Surface Combustion. Three Lectures. By Prof. WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S. (1914.) Price 1*s.*

Motor Fuel. Three Lectures. By Prof. VIVIAN B. LEWES, F.I.C., F.C.S. (1915.) Price 1*s.*

Coal and its Economic Utilisation. Three Lectures. By Prof. JOHN S. S. BRAME. (1917.) Price 1*s.*

The Shortage of the Supply of Non-Phosphoric Iron Ore. Two Lectures. By Prof. WILLIAM GEORGE FEARNSIDES, M.A., F.G.S., M.Inst.M.E. (1917.) Price 1*s.*

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FRIDAY, MARCH 8, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 13th, at 4.30 p.m. (Ordinary Meeting.) PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres and other Flemish Cities before and since the War." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] HIS GRACE THE ARCHBISHOP OF CANTERBURY will preside.

THURSDAY, MARCH 14th, at 4.30 p.m. (Indian Section.) WILLIAM FOSTER, C.I.E., "English Commerce with India, 1608–1658." The RIGHT HON. J. AUSTEN CHAMBERLAIN, M.P., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, March 4th; Mr. HARTLEY WITHERS, Editor of the *Economist*, in the chair. Mr. EDGAR CRAMMOND, Secretary of the Liverpool Stock Exchange, delivered the third and final lecture of his course on "The Effect of the War on the Economic Condition of the United Kingdom."

The lecture was followed by a short discussion, and on the motion of the CHAIRMAN a vote of thanks was accorded to Mr. Crammond for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

COLONIAL SECTION.

Tuesday afternoon, March 5th; SIR OWEN PHILIPPS, K.C.M.G., M.P., in the chair. A paper on "Portugal as a Colonial Power" was read by Mr. GEORGE YOUNG, M.V.O., ex-Secretary of Legation, Lisbon.

The paper and discussion will be published in the *Journal* of March 29th.

THIRTEENTH ORDINARY MEETING.

Wednesday afternoon, March 6th; The RIGHT HON. FREDERICK HUTH JACKSON in the chair. A paper on "The Foundation of Industrial Peace" was read by Mr. A. H. PATERSON, Secretary, National Alliance of Employers and Employed.

The paper and discussion will be published in the *Journal* of April 5th.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers will be supplied, post free, for 2*s.* each, on application to the Secretary.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1918 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 23rd, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K.C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
1868, Sir Joseph Whitworth, LL.D., F.R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul.

1874, Sir C. W. Siemens, D.C.L., F.R.S.
1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.
1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, Her Majesty Queen Victoria.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
1896, Professor David Edward Hughes, F.R.S.
1897, George James Symons, F.R.S.
1898, Professor Robert Wilhelm Bunsen, M.D.
1899, Sir William Crookes, O.M., F.R.S.
1900, Henry Wilde, F.R.S.
1901, His Majesty King Edward VII.
1902, Professor Alexander Graham Bell.
1903, Sir Charles Augustus Hartley, K.C.M.G.
1904, Walter Crane.
1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.
1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.
1910, Madame Curie.
1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.
1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.
1913, His Majesty King George V.
1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.
1916, Professor Elias Metchnikoff.
1917, Orville Wright.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, February 14th. 1918; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I., in the chair.

The Secretary of the Section announced that Lord Islington, who was to have presided, had been obliged to attend a Cabinet Committee Meeting, and, therefore, could not be present. Sir Charles Stuart Bayley had kindly consented, at very short notice, to take the chair.

The paper read was—

THE INDIAN HIDE AND LEATHER TRADE.

By Sir Henry Ledgard,

Late President, Upper India Chamber of Commerce.

I have in the following paper endeavoured to sketch the history and present condition of the hide and leather trade of India, but a few preliminary references to the cattle of other countries may be of interest, and at the same time serve to illustrate the very important position held by India in the leather markets of the world.

Broadly speaking there are but three classes of hides in the world: the heavy hide, yielding the stout, hard, strong leather from which boot soles, machine belting, harness, portmanteaux, etc., are made; the light hide, suitable for the upper leather of Army boots and many descriptions of civilian foot-wear; the sheep and goatskins for light foot-wear, gloves, bags, purses, upholstery, certain textile processes, and the innumerable uses to which thin flexible leather can be put. Of these three classes it may be said that India produces the great bulk of the light hides and skins.

It is, however, rather strange that while the British Empire yields the largest quantity of light hides and skins, the British tanner somewhat neglects them, and in the main devotes himself generally to the tanning of heavy hides drawn from foreign countries, notably the Argentine, South America, Italy, and France. We have also a certain quantity of our own unrivalled heavy "market hides" and imports from South Africa and Australia; but, as I have stated, the English tanner draws the bulk of his supplies of this class from outside the British Empire.

In the Argentine the conditions for the production of a perfect hide are more favourable than in many other parts of the world. The vast

herds of oxen are reared primarily for their meat. They are preserved for that purpose alone; they do no work, and when young and at their best are slaughtered. Contrast these conditions with India, where agriculture is by far the most important industry and the steam plough and motor tractor hardly known. About two-thirds of the 300 millions of population work upon the land, and the chief stock-in-trade of the cultivator are his bullocks. They plough the land, level and harrow it, sow the seed, raise water to the soil from the irrigation wells, tread out the grain, and finally cart the produce to market. For nearly all agricultural work the bullock is a necessity. He works throughout the greater part of the year, and the hard life of toil is often recorded on the hide of the dead animal in sores and scratches, scars or other disfigurements. In the Argentine, branding is practised as a means of identification. In India it is regarded also as a cure of various ailments. I have seen brands or sears aggregating 20 ft. in length, and in one case 40 ft. on one hide. Fortunately Indian cows and female buffaloes are rarely worked; hence their hides are generally in good condition. Neither are cows worked in the Argentine, but their hides are inferior to those of oxen, so we find cow hides may be deemed the better material for making into leather in one country and ox in the other. One other comparison is noticeable. In England, in normal times, the hide of a slaughtered animal may be said to represent about one-twelfth to one-tenth of the total value of the beast. In India, under similar conditions, the hide is worth a third; while on occasion, when cattle-feed is scarce and there is a brisk demand for hides, chiefly from Germany, the animals are slaughtered for the value of their hides alone.

The conditions in India to which I have referred tend to lessen the value of the hides. Nevertheless they produce the most suitable and economical leather in the world for the upper parts of Army boots and strong boots for agricultural labourers, miners, railway and postal employees, etc. The German realised this years ago, and some figures I will give you presently indicate the extent to which he acted upon his knowledge before the war, and, in the opinion of a good many, for a very considerable period after the war.

Our Home Government, however, until recently held a different view as to the uses of the Indian hide, and in their pre-war Army boot contracts barred out East India "kips" in favour of the heavy ox hide. Their inspectors, however, could not always tell the difference in the leather when in the boot, so, in spite of War Office specifications, "kips" were often used, when procurable, to shoe our soldiers. To-day our Government have commandeered these hides in India, are shipping them here, and are begging our English tanners to use them and to build new tanneries and produce all the leather they can for Army boots. Is it too much to hope that they will, before it is too late, go further and take steps to preserve this industry to the British Empire? The Indian hide export trade is not a small one. It ranks fifth in value of the products of India. It actually comes before tea, that magnificent industry of which we hear so much; moreover, are we not all interested in tea nowadays? Why is it that so little is known of the Indian hide trade? It is, as. I think I shall be able to show you later, because the business was to all intents and purposes a German monopoly.

It may be interesting to mention that the total value of Indian exports for the year before the war was £162 millions sterling, and that this amount was very largely made up of what are known as the six chief products of India. These six commodities accounted for £142 millions of the total exports, leaving only twenty millions for the less important articles such as shellac, coffee, gums, rosins, metallic ores, oils, spices, dyes, etc. Now, these six main productions rank in order of importance as follows: (1) Jute, raw and manufactured; (2) cotton, raw and manufactured; (3) food grains; (4) seeds; (5) hides and skins; (6) tea. Further, we should realise that, while over four-fifths of the tea exported finds its market within the British Empire, three-fourths of the hides and skins have been shipped to foreign countries.

How necessary, therefore, it will be in the near future to alter this and "to look after our own" is indicated by the result of a recent investigation undertaken by the American Government. From the *Leather Trades' Review* I learn that in their report serious attention has been called to the shortage the world may have to face in the future as a result of the great increase in meat consumption since the war began. It is estimated that the world's meat-producing animals have decreased in—

Cattle by	28,080,000
Sheep ,, ...	54,500,000
Hogs ,, ...	32,425,000
	115,005,000

Before the war the world's supply of hides and skins was barely equal to the demand, and prices were steadily rising. The figures I have quoted indicate a very serious shortage after the war. What will be our position when all the nations are replenishing their depleted stocks if our Indian resources are again in alien hands?

Hides and Skins in India.

I will now endeavour to confine myself more closely to India and the immediate subject of this paper.

The Statistical Department of India recently published the result of a census of cattle in British India, from which we learn that there were—

Bulls and bullocks	49,000,000
Cows	37,800,000
Young stock	42,900,000
Buffaloes	19,200,000
Goats	33,600,000
Sheep	23,000,000

These figures do not include the Native States, nor are we given the number of sheep in Bengal, or of goats in Madras. Official figures of these are apparently not available, but from the data supplied by the census I think, taking India as a whole, we may conclude that there are in the country 220 millions of cattle including buffaloes, and 80 millions of sheep and goats.

Curing and Preparation.

When an animal is killed, or dies, immediate treatment to preserve the hide is necessary. In the central parts of India, the Bombay Presidency, the United Provinces, the Punjab and Sind, where a dry climate prevails, the hides are usually what is termed arsenicated, *i.e.* they are cleaned of flesh, fat, etc., and sun or shade dried. Before baling for export they are dipped in a bath of arsenic solution and again dried. The arsenic acts as a preservative and prevents insects attacking the hides. This is considered the best method of treatment, as the hides keep well and there are not the opportunities for adulteration or weighting afforded by other cures.

In the damp climate of Bengal, and during the rainy season in other provinces, drying is difficult, so the hides are usually salted. The result is not always satisfactory; often a great deal of flesh and fat is left on the hide to absorb an excessive weight of salt. I have known a dry-salted hide weighing 15 lb., after the soaking in water, dissolving the salt, removing dirt, etc., which when again dried was found to weigh only 9 lb., or a loss of 60 per cent. The purchase of salted hides on a weight basis under these circumstances is not satisfactory. For this reason, in the United Provinces, where dry arsenicated hides are usually sold per 20 lb. weight, hides salted during the monsoon are valued by the piece, after selection and classification.

Classification of Hides and Skins.

For many years the Indian Government purchased large numbers of cattle, kept them where troops were stationed, fed them well for about three months, and then slaughtered them to supply beef to the British soldier. The hides from these, known as "Commissariats," were sold by public tender for a year to three years in advance, and these were the best in India. They were branded on the neck with the letter "C," and a number corresponding with the month when bought, and realised the highest prices. Many years ago the Indian Government discontinued buying cattle, but this term "Commissariat" remains in the trade and indicates the highest grade of hide. The next grade, known as "Slaughtered," signified that the hides were from slaughtered animals as distinguished from those which have died a natural death. The third grade was termed "Deads"; and still lower are "Rejections." These trade terms are still used by the chief hide markets in the central parts of India, the Central Provinces and the Punjab—though the classification has changed. For instance, Commissariat, though non-existent, still represents the best hides, and "Slaughtered" include the next lower grade of slaughtered hides and the best of those from animals that have died. The hides of Bengal, Maherpore, Chittagong and other districts have each their distinctive characteristics and are classified accordingly.

Of goatskins there are in India several varieties. The best are from the Province of Behar and known as "Patnas." They are fine in grain, and ideal for the production of glacé kid skins. Further east, in Dinagepore, Bengal and Eastern Bengal (including Dacca), the skins are somewhat larger and heavier in grain and texture, but still suitable for glacé kid. Passing westward into the United Provinces and Rajputana we find the skins also larger and rather coarser than Patnas, the lighter ones only of value for glacé kid. The heavier are suitable for "Moroccos" for the upholstery trade, but,

unfortunately, many have holes made by the pricks of thorns on trees where the animals feed. Further north in the Punjab the skins are known as "Amritsars." They are large, strong and heavy, and best adapted for upholstery. In the south, Hyderabad and Deccani skins are of fair quality, chiefly purchased by the Madras tanners, and tanned in Southern India.

The Indian Tanning Industry.

Before the war about three millions of cow, ox and calf hides yearly were tanned in India and exported. Since the outbreak of war the enormous and increasing demand for leather for military purposes, both for ourselves and our Allies, has entailed special effort on the part of the tanners in the Madras and Bombay Presidencies, the chief centres of the tanning industry. I think I am right in saying that, with the help of the Indian Government and the efforts of Mr. Wright Henderson, an expert specially sent from home, a splendid result has been obtained, as the present production of Indian tanned ox and cow hides is fully double that of the pre-war outturn. This industry is of such value to India that I trust a further expansion may be seen and the development maintained.

The primary processes, *i.e.* softening, liming, unhairing, fleshing and bating generally, resemble the methods which obtained in England until the introduction of labour-saving machinery. In India, where labour is relatively plentiful and cheap, the Indian tanner still adheres to the more primitive methods.

The tanning material chiefly used in Madras and Bombay is the bark of the *Cassia Auriculata* shrub, commonly known as tarwad. It grows to about 6 to 8 ft. in height, and has no trunk, the shoots breaking out a little above the ground. Shrubs of three to four years' growth are cut and the bark removed. Fresh shoots grow and are again ripe for cutting in about three to four years. Trees are usually destroyed when bark is taken from them for tanning purposes, so in this respect there is a distinct advantage in the use of tarwad.

I know of no tanning material more suitable than tarwad where softness and pliability in the leather are desired.

In the Bombay and Madras Presidencies it is the practice only partially to tan the hides, about half tanned according to our Western ideas; no exception is, however, taken to this as the European currier is able to complete the tanning to suit his requirements, and, perhaps, what is of some importance to him, to add considerably to the weight.

In addition to the Madras and Bombay tanning centres, there are some large and up-to-date tanneries and leather factories at Cawnpore in the United Provinces, well equipped with machinery and under European management. The first was erected over forty years ago by the Indian Government. There, cow and buffalo hides are tanned, curried and manufactured into equipment (other than boots) for the infantry, saddlery for the cavalry, and harness for the artillery and transport. In normal times the entire requirements of these branches of the Army in India are met in this factory. At present, and in addition, enormous quantities are sent abroad.

Later, the firm of Messrs. Cooper, Allen & Co., erected a similar factory for tanning and currying cow and buffalo hides, and the manufacture of boots for British and Indian Armies in India, Egypt and parts of the Far East. The effect of the war has been greatly to increase their operations, and Cawnpore boots are in every part of the world where fighting is going on.

The North-West Tannery is another large and important manufacturing concern devoted to war work.

The tanning materials chiefly used by the Cawnpore tanneries are the *Acacia Arabica* or babul, and *Terminalia Chebula* (the myrabolam nut). For firm leathers babul tannage is very suitable, and can, when toned down with other tanning products, be made to produce excellent upper leather.

There are also smaller tanneries in Cawnpore, and in Agra, Allahabad, Gorakhpur, and Calcutta.

Owing to the great impetus given by the war to tanning, the cutting of tarwad has been very much increased, and I hear there has been a considerable rise in price. In the north, the Cawnpore tanneries have year by year to go further afield in search of babul. Neither of these two tanning agents, so important to the industry, are systematically cultivated. Tarwad is a jungle plant, flourishing in the central parts of India. Babul, a tree scattered over a wide area, chiefly in the northern parts of India, is not ripe for cutting until ten to twelve years old.

Private enterprise will not cultivate the babul tree and wait so many years for a return, nor have I heard of any enterprising Indian tanner taking in hand the plantation cultivation of

tarwad. It is obviously the business of the Indian Forest Department, and I sincerely trust the Government of India will realise the importance of the tanning industry, and assure to it an ample supply of tanning. India can produce the bark, but its exploitation should not be left to private enterprise.

In addition to the tanning centres of Bombay, Madras, and Cawnpore, there still exists, mainly to supply the local needs of the districts, the primitive system commonly known as "country tanning," carried on in the villages. The hides and skins, after the usual preparation, are sewn into a bag, hung up, and filled with water and ground bark. The liquid extract percolates through the hide; twenty-four hours' suspension in the case of cow hides, and forty-eight with buffalo, completes the process. The hides are coloured and look tanned, but a true chemical combination has not taken place. That they are not properly tanned is indicated by the unpleasant smell they give off for a long time. This leather comes to London from time to time in small quantities, where it is known and sold as "stitched hides," or "bag tanned."

Of the three centres of tanning I have reviewed, the Madras and Bombay *Cassia Auriculata* tannage is the largest, and meets an important demand in Europe. The second is a sound tannage, but has a limited market. The third is inferior, only of value where better leather is not available, and will die out as the better tannages find a wider market in India.

Chrome tanning is carried on to a small extent. In this direction there would appear to be great possibilities for India. The adoption of Western attire has led to a considerable increase in the use of boots and shoes of European pattern, and there is no material more suitable for the upper parts of boots and shoes in a hot climate than the soft, flexible leather produced by chrome tannage. Apart from this fact, it is a mineral tannage, and can be extensively developed without adding to the present and increasing demand for the vegetable tanning agents to which I have alluded.

Export Trade.

I now turn to the export trade, which comprises (1) the hides or skins tanned in India, and (2) the raw hides or skins exported and tanned abroad.

Of goatskins, India, previous to the war, exported annually some 20 million pieces in the raw state and 7,500,000 tanned.

The United Kingdom took the greater part of the tanned skins. They were practically all sent to London and disposed of at the public sales held at intervals of one to two months. About half the skins were re-exported to the Continent, and America took about one-third of the remainder.

The handling of the raw skins was on a different footing. America imported direct about 75 per cent., England 10 per cent., France 7 per cent., Holland and Belgium 5 per cent., Germany an insignificant quantity. Since the war America's imports have risen to 88½ per cent., and ours dropped to 8 per cent. or less.

The very large quantities taken by America are turned into glacé kid, and of these England takes annually from America, for her own use, a considerable proportion, valued at £1,500,000.

Of sheepskins the export in the raw state, previous to the war, amounted to 2,200,000, and about 9 millions tanned. Of these raw skins America took in 1913–14, 87 per cent., and in 1915–16, 96½ per cent. In face of these American figures I do not think it necessary to tell you what England imported. The treatment of the tanned skins is rather more favourable. The following are the figures:—

	1913-14.	1915-16.
United Kingdom	58·9 per cent.	64 per cent.
United States	20·9 ,,	19·8 ,,
Japan	15 ,,	11·8 ,,

As with the tanned goatskins, a considerable percentage were re-exported to America and to Austria, and then came back to us in various forms of useful and fancy manufactured articles.

Of buffalo hides about 16,000 cwt., or 160,000 pieces, were exported to England in the tanned state. Unlike sheep and goat skins they were nearly all absorbed in the country. Of the 345,000 cwt. raw hides, representing about two million pieces, the position is fairly summarised when I say that half the number went to the countries now at war with us, one-third to the United States, the remainder to the United Kingdom, Holland, and Italy.

Before referring to the export of ox and cow hides I should state that efforts are being made to increase the manufacture of glacé kid in this country. The chrome tanners have considered the position, and state that they are prepared to extend their factories and deal with an additional five million goatskins per annum, provided Government give them some security for the capital involved. The Tanners' Federation

consider that such security would be provided by an export duty in India on all raw goatskins, with a rebate of the full amount if the skins are tanned within the Empire. The Federation estimate that the value of the increased production in this country would, within three years of the termination of the war, fully equal the cost of the Indian goatskins treated in America and imported into this country in the form of glacé kid, to which I have alluded.

A similar fiscal policy is suggested in regard to sheepskins, and in both goatskins and sheepskins there is a very considerable industry to be created in this country in the manufacture of fancy leather articles, such as bags, purses, etc., a trade hitherto largely in Austrian and German hands.

The Tanners' Federation have also considered buffalo hides, and, in view of the fact that all imported tanned hides have so far been absorbed in this country, express the view that a very much greater number of Indian buffaloes could be handled here if the trade were established with the certainty of supplies in the future.

I now come to ox and cow hides, by far the most important branch of the hide and skin exports of India. Covering a period of some years before the war, the exports have been approximately 11 millions, of which about 3 millions of hides have been exported in the tanned state, and the remaining 8 millions in the raw. Broadly speaking, the tanned hides came to this country, and the 8 million raw hides went to the Continent. At one time, you may be interested to know, all the hides came here, and kip tanning was a most important industry. From the Leeds district alone the outturn was about 3 millions per annum. Kip, I may mention, is the trade term for Indian ox or cow hides.

In 1872 the shipments to the United Kingdom were 7 millions; to other countries none. Ten years later, in 1882, 5 millions came here and 1 million went to the Continent. By 1892 the figures were almost reversed, for 1,038,417 came to this country and 4,423,159 went to the Continent. For about three years longer our imports held up, and we averaged about 1¼ millions against 5 millions to the Continent. In 1896 we dropped to 681,000. Imports continued to dwindle, until in 1913 we imported only 17,530 as against 6,981,947 to the Continent and 261,060 to America.

I have here the details of statistics of exports from Calcutta going back to 1872, but not to weary you with so many figures, I have summarised them in the preceding column.

Shipments of Raw Ox and Cow Hides from Calcutta.

	To the United Kingdom.	To Continent.	To America.	Total.
1872	7,000,000*	Nil.	Nil.	7,000,000
1882	5,000,000*	1,000,000	,,	6,000,000
1887	3,882,443	1,614,363	,,	5,496,806
1888	3,552,956	1,645,880	,,	5,168,836
1889	3,915,367	1,678,485	,,	5,593,852
1890	2,694,554	2,440,315	,,	5,134,869
1891	2,444,148	4,301,734	,,	6,545,882
1892	1,038,417	4,423,159	,,	5,461,576
1893	1,437,317	4,872,637	,,	6,309,954
1894	1,591,011	5,628,416	,,	7,219,427
1895	1,424,719	5,784,802	,,	7,209,521
1896	681,164	5,315,552	,,	5,996,716
1897	700,086	6,181,250	,,	6,882,336
1898	683,266	6,932,099	,,	7,615,365
1899	700,000	6,817,000	335,000	7,852,000
1900†	433,636	9,677,840	464,810	10,576,286
1901	227,748	6,752,912	127,326	7,107,986
1902	90,070	6,035,341	92,340	6,217,751
1903	144,216	6,600,901	97,967	6,843,084
1904	136,794	6,671,278	13,532	6,821,604
1905	174,888	7,719,582	105,007	7,999,577
1906	337,047	9,946,681	331,111	10,614,839
1907	197,569	7,344,460	24,670	7,566,699
1908	215,834	7,081,005	5,760	7,302,599
1909	166,466	7,257,783	26,970	7,451,219
1910	98,772	7,721,097	21,172	7,841,041
1911	135,134	8,159,231	194,100	8,488,465
1912	39,583	7,812,626	801,221	8,653,430
1913	17,530	6,981,947	261,060	7,260,537
1914	154,211	5,676,395	343,096	6,173,702
1915	408,603	4,192,949	1,322,216	5,223,768

German Control.

The figures I have quoted show that the trade in raw hides had passed from us when war broke out. What the trade meant to the enemy may best be expressed by indicating what these hides would produce.

The ox and cow hides that went to Hamburg, Bremen, and Trieste in the three and a half years before the war, after making the liberal deduction of 50 per cent. for hides unsuitable for military requirements, yielded sufficient leather to make 48 millions of Army boot

* Estimated.

† In 1900 (the famine year) upwards of 3,000,000 raw hides were shipped from Bombay.

uppers, while the buffalo hides exported to the Continent would supply 49 millions of Army boot soles. Of the remainder, fully half were suitable for making civilian upper leather (of which a large quantity was returned to us in the form of finished box calf), and for making soles for light boots and shoes or the inner soles of heavier boots. How this complete capture of trade has been accomplished is of interest. In 1876-77 the German Government imposed an import duty on leather of 6*s.* 1*d.* per cwt., equivalent to about 6 per cent. *ad valorem.* In 1878 they increased it to 10 per cent. *ad valorem*, and in 1906 the tariff was revised and increased, raising the duties to from $1\frac{5}{8}$*d.* to $2\frac{3}{4}$*d.* per lb. according to the weights of the tanned hides.

Concurrently with these fiscal measures in Germany there arose in Calcutta German firms devoting themselves exclusively to the export hide trade. Before long they had banded themselves into an association or ring almost exclusively German. In case this description of the ring may be questioned, I give you the grounds for my assertion. In 1913 the firms composing this association contained thirty German or Austrian directors, partners or managers, and four naturalised or not German. Of assistants other than Indian clerks, hide sorters, or coolies employed, there were fifty-five German and Austrian and only twelve naturalised or not German. In addition to the association of German hide merchants in Calcutta, a Tanners' Association existed in Germany and a Dealers' Association in Hamburg. The latter worked with the Calcutta ring, and any outsider attempting to do business found himself against the Calcutta association or its counterpart in Hamburg. The Calcutta firms very naturally cultivated intimate relations with their Continental customers, and drew their assistants from Germany or Austria. The hide classifications were made to suit the German tanners. A German line of steamers carried the hides direct from India to the German or Austrian ports. It is true the ring would sell to English tanners or anybody else, but in all essentials it was Germanic in its origin, in its organisation, in its sympathies and ramifications. There was one exception in this co-operative system, and that was in finance, where the German houses apparently found the English banks sufficiently cosmopolitan and wealthy to serve their purpose. If I have wearied you with these details it is from a strong desire that you may understand how completely the trade was dominated by Germany, and realise the very poor outlook if nothing is done to free us from the German incubus. The fight will be short and sharp, and certainly end in a German victory. The Home Government has apparently given more consideration to the subject than the Indian. Possibly the leather shortage over here has been the stimulus. It is not, I think, unfair to say that the Government of India has so far done little with the weapon in their hands in the shape of the "Hostile Foreign Traders' Order." Shortly after the outbreak of war they ordered the liquidation of four German firms out of those comprising the ring, but soon, and, I take it, with the knowledge of Government, other concerns started. How the firms affected regard the changes may, I suggest, be inferred from the following extract from a circular of one of them ordered to be wound up under a Hostile Traders' Order—

"There will be no change in the management, and we trust the new company will receive the same measure of confidence and support hitherto enjoyed by ourselves."

The remaining firms composing the German ring have been allowed to trade, some with, some without, supervision.

Possibly, in the early days of the war, to have entirely shut down the European hide merchants in Calcutta might have caused serious dislocation before new markets had been found and new organisations formed, but that reason no longer exists. The Government are themselves the purchasers, with the aid of British firms, of all the available ox and cow hides, and there is in England and in neutral countries an eager demand for such as are not required by the Government.

In February 1916, with the concurrence of the India Office, an influential and representative committee was formed at the Imperial Institute, including representatives of firms interested in this Indian trade, of tanners in this country, and others qualified to consider the future of the trade in Indian kips.

On July 3rd, 1916, a conference was held at the India Office, under the chairmanship of Lord Islington, which discussed a memorandum prepared by the committee setting forth the ascertained facts of the case. It was then settled that the committee should proceed to ascertain :—

1. Whether British firms would be prepared to take up the raw hide trade in India, and purchase the kips for export.

2. Whether tanners in the United Kingdom would be prepared to take up the tanning of the Indian hides on the large scale required.

The results of the committee's inquiries on these two points were entirely satisfactory, and have been embodied in an important report and recommendations presented to the Secretary of State for India, which so far has not been published. British firms in Calcutta of undoubted reputation informed the committee that they would take up the export trade, and stated their views as to the best methods of securing that in future the East India hide business shall be an all-British industry. At the same time they made it quite clear that their entrance and continuance in the business would be contingent upon the complete removal from the trade of German firms, or firms whose antecedents and connections and membership of the German hide ring set them apart from British firms.

Tanners in this country express their readiness to tan these kips on an increasing scale under certain conditions, the most important of which is that the purchasing trade in India shall be in the hands of entirely British firms free from previous or present German connections.

The United Tanners' Federation of Great Britain and Ireland expressed themselves able to handle increasing quantities up to four millions in the third year after the conclusion of the war, subject to:—

1. The imposition in India of an export duty on raw hides which shall be remitted if they are tanned within the Empire.

2. Confining the export of raw Indian hides to British firms free from any German or Austrian connections. (The term "British firms" is meant to include Indian.)

3. The granting, where necessary and advisable, of financial assistance to tanners, adapting their yards or building tanneries to tan East India hides.

In this report the committee also laid stress upon the importance of the fullest development possible of the tanning of kips in India which shall involve the employment of Indian labour and capital in the manufacture of leather goods from Indian tanned leather. Since the committee's recommendations were submitted, the Government of India have employed only British and Indian firms as their agents in the purchase of hides on the Government account. In the background there are, however, still the old ring firms or their successors resenting their exclusion, agitating for recognition, bringing pressure upon Government, trading with neutrals, and ready to pounce upon the trade (of which they had the monopoly) directly peace is declared and the Continental market re-opens. The Tanners' Federation in this country are under no delusion as to the danger, and recently passed an outspoken resolution to the effect that if "German" firms are included in the buying arrangements in India, and the trade in India is not firmly established in British hands, they will not enlarge their yards and sink capital in order to tan Indian kips.

That is the position to-day of this vast trade. I hope I have succeeded in raising in your minds a desire that it should be retained for the Empire. If I have done so it is incumbent upon me to do more than criticise, and to ask you to bear with me a little longer while I outline a policy that would, I think, give to us at least a measure of that control so long exercised by the enemy.

The Remedy.

In the first place, I urge that no German firm, or firm of German antecedents and connections, shall be permitted to remain in this trade. In precisely defining what I mean, I cannot do better than quote from a speech of Lord Islington on July 18th, 1916, in the House of Lords, when dealing with the case of a German firm in Calcutta that had been engaged in supplying manganese ore to Krupps for the manufacture of steel. He then said—

"The Government of India had long prevented hostile firms carrying on business in India for the benefit of enemy interests; but, for the purpose of determining what was a hostile firm, they were taking as a criterion whether a firm's business was carried on before the war for the benefit of an alien interest and was likely to be resumed on similar lines after the war."

In quoting this admirable definition of a German, or pro-German firm, I must, however, be permitted to say I do not altogether endorse his lordship's statement of what the Government of India have done. I would rather suggest that it is what they may do if sufficient pressure is brought to bear upon them.

Secondly, I recommend that no concern or individual should be permitted to be in this trade in India without a licence, and the conditions attaching to a licence shall be—

(a) That the capital of the licensed company, firm, or individual, shall be entirely British. (The term "British," of course, to include Indian.)

(b) That all partners, directors, or managers of such licensed company or firm shall be British, and without German connection.

(c) That no British subject being under direct or indirect control, financial or otherwise, of foreign interests, shall be allowed to have any share of the capital, or be a partner, director, or manager of such licensed company or firm.

(d) That no license to trade in Indian raw hides shall be granted to a company, firm, or individual who before the war carried on, or was engaged in, the business for the benefit of foreign countries taking part in the war against the Allies.

I may point out that, apart from the main object we have in confining the trade to licensed firms, other advantages are likely to accrue. There would, for instance, probably arise an association not existing for the purpose of maintaining a monopoly, but instead devoted to the development and improvement of the industry in the interests of all concerned, as exists in the tea industry.

Mr. Chadwick, in this room on December 13th, drew attention to the extent to which adulteration is practised in India. The hide trade is not immune, and I have drawn attention to certain malpractices. All the excessive weighting, bad curing, bad flaying, etc., and the evils emanating from them, would all come within the purview of the association, and the remedies besought to improve the quality of the hides would increase their selling value, and if, say, only one shilling per hide were added, I leave it to those with a taste for figures to estimate the sum that would reach the pockets of the cattle-breeders and hide-sellers of India.

Thirdly, a careful consideration of the fiscal policy outlined by the Tanners' Federation as essential to the revival of the light leather tanning industry in England and its expansion in India.

There is nothing revolutionary or impracticable in these proposals. They are, in their main features, already embodied in the Non-Ferrous Metal Bill, which has met with general approval and received Parliamentary sanction as a measure of protection in the best sense of the word.

Finally (and in this I have in mind the trade of India as a whole), there should be closer commercial union, some preference or privilege—call it what you will—that will render us more self-supporting and self-contained, more independent, and, let me add, more alive to enemy machinations than we have been in the past.

DISCUSSION.

The Chairman (Sir Charles S. Bayley) said the paper formed a very valuable contribution to the knowledge at present existing of one of the leading Indian trades, of its growth in the past and of its possibilities of future development. The subject naturally divided itself into two branches—the tanning trade and the export trade in raw hides. The author had shown the importance of the tanning trade by the various figures he had given in the paper, and to that information he would only add that he had been informed that Indian tanned hides were now providing some 60 per cent. of the material required for the upper leathers of Army boots. The subject was one that had claimed the special attention of the Indian Munitions Board, whose vigorous action in controlling the industry could not fail to stimulate tanning in India, and would probably do much to improve the methods at present employed, of which the author had given such an interesting account. The question might have occurred to some whether there were sufficient hides in India to supply both the tanning and the export trade. The author had stated that the recent census of cattle in India showed that in British India alone there were something like 220,000,000 cattle, which proved that for the present at any rate there was an ample supply of hides, and he did not think that there need be any apprehension whatever about the future. England and India were both vitally interested in the tanning trade, and should do all they could to encourage it. Equally they must wish success to the raw hide export trade, and to the endeavours which were now being made to divert that trade to British tanneries. The author had shown that for many years past the raw hides had been finding their way to Germany in increasing numbers, and certainly the position was a very remarkable one. In the year 1887, about 70 per cent. of the raw hides of India were exported to England, but in the year 1913, the year before the war started, the proportion was ·02 per cent. He did not know why it was that the English firms had allowed so valuable a trade to pass out of their hands: the fact remained that it had gone, and it was of the utmost importance that the circumstances to which the war had given rise should be used to revive it, if possible. The Government of India had given their fullest consideration to the matter, and had taken exceedingly drastic steps to purge the firms engaged in the trade from enemy influences. The matter, however, was a very difficult one, and there were obviously considerable opportunities for differences of opinion as to the further steps which should be taken. The individual cases mentioned by the author were under consideration, and were no doubt being dealt with as well as possible. The author had advocated certain concessions to the trade, and he was quite justified in doing so. The concessions might or might not be expedient in themselves, but it was certainly very desirable that the whole matter should be fully ventilated and discussed.

He could not help thinking that anyone who had listened carefully to the paper must see that the concessions suggested would involve very big consequences indeed, and that they also involved the application of certain principles which could not be confined to any single trade. For example, the suggestion that an export duty should be imposed on raw hides shipped from India, and that a rebate should be allowed if the hides were tanned within the Empire, might be a most excellent thing, but there was no doubt that other trades would apply for a similar concession, and it was a matter of high policy whether a general application of that principle would be a good thing or whether it would in any way interfere with the export of raw produce from India in the hide and other trades. That was a point that required careful consideration. Then again, the author had suggested that the export hide trade should be confined to firms of purely British origin, and had quoted, in support of that view, a speech made by Lord Islington in 1916. It must be remembered, however, that Lord Islington delivered that speech two years ago, and perhaps he would not say exactly the same thing now. The position had wholly altered during the last two years. In 1916 America had not come into the war; now she was fighting by our side, and the question arose whether we were to treat American firms in precisely the same way as German firms. He thought that if Lord Islington were speaking at the present time he would probably substitute the word "enemy" for the word "alien" in the passage quoted by the author. That, again, was a question of high politics that had to be very carefully considered. All were absolutely agreed as to the great importance of eliminating enemy interests of every kind, and he felt certain that the Government of India would take every step it could with that object in view; but the question of the elimination of all alien firms was a very large one, and one which he at any rate could not discuss at the present time. Everyone would unite in hoping that any conclusions at which the Government of India and His Majesty's Government might arrive would be framed in the best interests of India, of the whole Empire, and of the great industries amongst which the hide and leather trade must certainly be included. It was to be hoped that the present war, with all its disastrous results, would at any rate help to draw the Empire together, and make it self-supporting and encourage and forward its trades in every way.

Mr. H. Percy Densham (Chairman of the United Tanners' Federation) said the author had mentioned the views expressed by the Tanners' Federation on many points, and since those views were first put forward the trade had progressed still further, and was already producing leather satisfactorily from the East India kip. If the requisite protection, not necessarily in the way of duties, could be obtained, the Federation intended to build up that trade. The chief protection it asked for was that the handling of the raw material should be entirely in the hands of British firms; without that protection the trade could not be increased. A great deal had been said about the value of the East India kip for Army boots. If this war proved to be the last war, as everyone hoped it would, the leather made from the East India kip would still be very valuable for the civilian trade. The suggestion had been put forward in the paper of an export duty on raw hides shipped from India, with a rebate to users in the Empire, and the Chairman had expressed a doubt whether that would be advisable, seeing that the United States had now joined the Allies. While agreeing that it might be right that our Allies should receive consideration, he thought the first thing we ought to look forward to for the reconstitution of the Empire was the conservation of our raw materials primarily for the people of the Empire, and we had a perfect right to ask for some such consideration. The author had pointed out that the number of live cattle in the world had been seriously reduced, and that there would probably be a shortage of hides. Further than that the consumption of leather owing to the war had enormously increased, and, therefore, there was bound to be a shortage of leather. India was one of the greatest raw material producers in the world, and it was very desirable that that raw material should be conserved for use in the Empire. Perhaps rather more weight had been given to the question of the East India kip than to that of goatskin, but he was glad to be able to report that the glacé kid manufacturers of this country were prepared to go ahead to an enormous extent if a reasonable amount of protection and perhaps financial assistance were given to them by the Government. It seemed absurd that 75 per cent. of the 20,000,000 goatskins produced in India should go to the United States, and that this country should then take from America a large proportion of the glacé kid produced from that material, when the process could quite well be carried on in this country. With regard to buffalo hides, they were useful for many purposes. They were absolutely essential for the making of pickers and buffers for the cotton and woollen trade, and they could be tanned into a sole leather, either by the vegetable or by the mineral process, suitable for wear in dry and sandy climates. The leather producers of this country were prepared to take the matter up seriously, and greatly increase their consumption of that material. They were also anxious that the resources of India herself should be developed; they were not asking to have the raw material at the expense of the Indian Empire. They wanted India to manufacture or semi-manufacture the leather as far as possible, and then they wanted any surplus raw material there might be to come to them. With regard to the vegetable-tanned goatskin, that was absolutely essential for the fancy leather trade, there being no skin in the world which was so adaptable for the manufacture of all classes of

fancy goods. Unfortunately, that trade in the past had been largely in the hands of the Germans, but during the war successful efforts had been made to increase the trade in this country. The war had proved the value of woman labour in that industry, as in others, and woman labour was going to enable this country in the near future to compete freely with the cheaper productions of other countries, and to meet the home demand for fancy leather goods by the products of our own labour.

SIR J. D. REES, M.P., said the issue arising out of the paper was whether the important trade with which it dealt had been released from the German domination under which it had fallen, and, if so, to what extent it had been released. Had those shackles been removed so that the Germans would not be able to take possession of the trade again after the war? He had been personally much interested in the subject, and had asked questions in Parliament as to what was being done about it. The Government of India had placed the matter in the hands of a committee consisting of merchants who had no German taint about them, but there was a feeling now that the Government had somewhat faltered upon its path, and he would like to feel certain that the Government of India and the India Office were determined to rescue the trade from the hands of the Germans. It was a very serious matter that, whereas in 1872, 7,000,000 hides were imported into the United Kingdom from India, in 1915 those importations had decreased to 408,000, and 4,000.000 hides went to the Continent, chiefly to Germany. If the recommendations contained in the paper were carried out, a great deal could be done to foster the cause of British trade in India, which he was old-fashioned enough to think ought to be chiefly in British hands.

SIR EDWARD PENTON, K.B.E., Royal Army Clothing Department (Boots), said this country owed a great debt of gratitude to the author for his untiring energy, his wise advice, and the great help that he had rendered to the War Office since the beginning of the war in regard to the supply of Army boots and the provision of leather. There was no man in the Empire who had a wider experience of leather equipment for the Army than the author, and when the War Office embarked on a very much more extensive use of the East India kip he gave very full information, which enabled them to work with that particular leather satisfactorily. When the war began the Government had two patterns of boots, one made from a British market hide, known as shoe butt, the other from a fully chrome-tanned hide. At that time the upper leather industry of this country was not adequate to supply the amount of upper leather required, and a very large quantity had to be imported; but when, later on, it was decided to use in very large quantities the East India tanned kip, this country made itself self-supporting as far as the leather required for Army boots was concerned, and it also supplied leather for the boots of a good many of the Allies' troops. The East India kip had been probably more serviceable to this country as a vegetable tannage, because the bulk of the hides were comparatively light, at any rate as compared with the British market hide. Great Britain owed a considerable debt of gratitude to the Indian Empire for the hides, both tanned and raw, that it had supplied, without which we should not have been able to do all that we had done as regards the booting of our own Army and that of our Allies. He agreed with the Chairman that about 60 per cent. of the material required for the British Army boots was obtained from Indian tanned hides. If the members of the tanning trade and of the leather trade generally who were present would go away from the meeting with a determination to do a little self-examination as to why the trade had been lost to such a great extent, he thought the paper would have done a great deal of good. It was probable that the trade had been lost through lack of imagination; there was no doubt that British traders did lack imagination, and very often allowed a trade to slip out of their hands because they could not project their minds into the future and see what would be the result of a certain process. His own view was that the tanning trade slipped out of our hands with the introduction of chrome tanning, when the average British tanner thought he could do a little chrome tanning in an odd corner, whereas the Germans adopted the process on a large scale.

MR. CECIL J. LONGCROFT (Messrs. David Sassoon & Co., Ltd.) thought that the hide and leather trade illustrated what had happened in many other trades. The people of this country had not recognised that in dealing with a trade it was necessary to analyse it and see whether it was of a character that was desirable for the Empire. They had been contented with aggregates of figures and had neglected the making of a careful analysis. As in the case of other trades, this country had allowed the leather trade to pass into the hands of aliens, and had bought cheapness at too dear a price. We had been too much inclined to buy German leather at the very cheapest price, when, with a little more enterprise, we might have produced the leather ourselves. With regard to the export trade, it was undoubtedly in the hands of German firms when the war broke out; the Government found that out because they had either to liquidate or licence all the firms in the trade. He thought they ought to have taken their courage in both hands and closed down all enemy firms, thereby giving to the British firms who proposed to start an opportunity to acquire the organisation and the labour that had been in the trade. By reason of the hesitancy of Government, those firms that entered the trade had never felt secure of their position. If a purely British firm were asked to enter the trade they

said, "We have no confidence in the Government: we do not believe that the Government intend to do what they say they will do." A buying committee was set up by the Government in Calcutta, but it had only been in existence for about three or four months when the Government proposed to take action to close it down, It had apparently carried on its work satisfactorily; no charge of incompetence had been made against it, and it imagined that its existence might be prolonged considerably. The committee felt that at the present time it was in a state of suspended animation, because the officials of the Government had not yet declared what their policy would be in relation to the trade. It was very difficult to trace the reasons actuating the Government in adopting their present attitude towards the trade, and especially in their attitude towards purely British firms who had entered the trade for the express purpose of making good the deficiencies produced by the liquidation of enemy firms. Unless that question was approached rather from the standpoint of commercial interests than of official interests the trade would not make the advance it might otherwise do. There had not been a single case in which the Government had had to complain of the shipments of British firms. There had been a reasonable expansion in the trade, but further expansion would be very much hindered unless the Government made up its mind finally to extirpate all German influences. When once a trade passed into British hands it was dealt with in a broad fashion. For example, whilst the Germans were carrying on the trade very little was done in the way of reform, but as soon as British firms entered the trade and got into touch with the Government expert, Mr. Wright Henderson, two or three reforms were introduced at once. First of all, there was an abolition of the unduly complicated classifications of the Germans, who had two or three hundred classifications; and, secondly, at the instance of the Government a scheme had been introduced by which the branding of the cattle could be conducted on much better lines. British traders were not necessarily narrow, as some people supposed, and at least two firms had entered the tanning trade in India with the object of developing that trade in the interests of India. If the Government would take its courage in both hands and see that the trade was confined to purely British firms, they would have no reason to regret it. On the one hand the tanner would be sure of his raw materials, and on the other hand the Government would know that if, in the event of another war, they required a large quantity of leather, they would not be so entirely at the mercy of the German element as they were when the present war broke out.

On the motion of Mr. S. B. Leigh Taylor, seconded by General Sir Edmund G. Barrow, G.C.B., G.C.S.I., thanks were accorded to Sir Henry Ledgard for his valuable paper, and the meeting terminated.

WATER-SUPPLY FOR IRRIGATION AND POWER IN SOUTH-EASTERN AUSTRALIA.

Australia will, sooner or later, be bound to receive emigration on a great scale from this country, and also to absorb the surplus of some of the 360,000 soldiers which she has sent to the war. Hence the extra settlement on the land after the war is concluded is most essential.

The country referred to in this article may be divided into two regions—that moderately supplied with rain, and the arid portion, the former being chiefly adjacent to the coastline and of undulating character, rising in many parts to the magnitude of mountains. The comparatively arid interior, which is the larger in area and fairly level in feature, is for the most part given over to sheep and cattle, whereas the upper country is at present more or less cultivated by tillage. The rainfall in these flat districts is light, but also particularly rich in plant food; the only thing wanting is water. The water must be gentle in its application, like that of light rainfall, so that it may not wash away the soluble constituents of the ground into the rivers, thus retaining them in the soil. The conclusion is plain. The water must come from hills to the plains, by gravitation or pumping, preferably by the former, as the latter is expensive. It should be borne in mind that the supply must be very ample, in order to compensate for the evaporation which takes place in marshes and lagoons under the fierce sun of the interior, to the extent of nearly half an inch daily. So great is this evaporation, that, contrary to the ordinary nature of rivers, in this case the streams contract as they flow down to their outfall, the opening of many road and railway bridges, in accordance with this peculiar feature, being decreased as the river's mouth is approached.

Dr. Johnson's remark as to the possibilities of a Scotchman is applicable, in a special sense, to the youth and the training of such rivers as these, which may be caught by dams while still in the mountains, thus preserving their valuable flowing waters for irrigation, which would otherwise run to waste.

The most important irrigation scheme yet undertaken, and now almost complete, is the damming of the Murrumbidgee River at Burronjuck, New South Wales, the description of which was given in our columns in the summer of 1913. As that is over four years ago, the chief features may now be briefly recalled. The storage dam is of concrete of gravity section, 240 ft. high, the river affording a channel 220 miles long, which gives access to the rich chocolate, but semi-arid, lands beyond, the intervening district needing no irrigation, as it is plentifully watered. The height of the dam is considerable, and therefore very suitable for a power scheme. This may be utilised elsewhere as a gravitation project in South-Eastern Australia, when joy bells are ringing and joy cars are running for peace and plenty. The work has been much

delayed by the war, owing to the diversion of labour and the raising of the Australian contingent of 360,000 men, but it has now been, fortunately, almost finished, otherwise the concurrent expenditure on the fighting must have been difficult to meet.

The storage reservoirs on the upper Goulburn River in Victoria are the only works at present in operation as a gravitation undertaking which permits of power facilities.

The first settlement of the pumping station of Mildura, Victoria, for irrigation purposes from the Murray River, was carried out in 1884. The area of the settlement is 45,000 acres, of which over 12,000 acres are under intensive culture, principally fruit.

The Ronnark Irrigation Trust, South Australia, is also pumped from the Murray. The district served is 5,270 acres.

The main irrigation works in Queensland are as follows: Those at Ayr, which utilise the waters of the Burdekin River; those at Bingera, near Bundaberg, which utilise water pumped from the Burnett River; and those at Fairymead, which utilise water pumped from a number of shallow spear wells sunk on the alluvial flats on the north side of the Burnett River, and about six miles from Bundaberg. There were in all 11,000 acres for irrigation.

The projects in contemplation are numerous, and only await realisation when immigration is to the fore and available funds are in hand. They are altogether in the State of New South Wales, and are as follows:—

Darling River, of which a preliminary investigation has been made. Lakes Boolabooka, Ratcatcers, and Victoria, and a number of other lakes fed from the river in high floods from the Talywalka Creek, which takes off from the river about 260 miles above Menindie, are available for irrigation.

Lachlan River is also to be made the site of a storage reservoir at Wyangala.

The construction of a storage reservoir serving the Macquarie River, at Burrendong, for the purposes of irrigation by gravitation, is also proposed.

Hunter River: a scheme has been prepared for providing water by means of pumping from the river, the valleys of which are the most fertile districts in the State, and are capable of carrying a dense population under the conditions of intensive culture by irrigation.

Naomi and Peel Rivers: surveys have been completed for storage dams on the Peel River, near Bowling Alley, and the Namoi above Manilla.

The Warragamba River project will serve the dual purposes of amplifying the Sydney water-supply, and irrigating the best lands in the Hawkesbury Valley. It is proposed to construct a large storage dam, capable of supplying at least 80 million gallons daily for domestic service, 30 million gallons daily for trade purposes, and 80 million gallons daily for irrigation.

The water from the artesian area, which is included in the district referred to above, is not sufficient for agriculture; it only serves to supply sheep and cattle.

ECONOMIC VALUE OF GRASS TREES.

The economic value of grass trees has formed a subject of investigation in South Australia, and as a result an interesting treatise has been issued by the Department of Chemistry in that State. Attention was drawn to the matter (says the Sydney *Morning Herald*) on account of the fact that the resin known as yacka gum appears likely to be of considerable commercial importance in the future. Among the many interesting facts mentioned by Mr. J. C. Earl, the officer of the department who was entrusted with the work of investigation, is that grass trees are not found outside Australia, and that therefore their study is a peculiarly Australian problem. They yield products the like of which are not obtained from other plants. On account of their slow growth there is little danger of any industry built up on their systematic exploitation being filched from Australia, as in the case of the eucalyptus oil industry, by the establishment of plantations in other countries. There appears to be some likelihood, however, that by the time this national asset is fully established the trees will have been practically exterminated in many places by careless destruction. Large numbers of these stunted growths, for instance, were destroyed in the clearing of the land for soldiers' homes at French's Forest.

The only product at present of commercial importance is the resin, variously known as gum acaroides, yacka gum, and grass-tree gum. Previous to the present war, by far the larger part of the output of resin gum was consumed by Germany. The purposes for which it was used are not known with any certainty. Inquiries made in 1910 led to the explanation that it was used chiefly in Germany for colouring wine. It is difficult to justify this explanation practically, as the resin is not soluble in dilute alcohol of the strength of wines. More recent inquiries indicated that the main use in Germany of the resin was in the manufacture of cheap furniture polish and lacquer for metalware. It is not certain, however, that other uses of which we are not yet aware were not found for it. Resin derived from a species of grass tree was one of the earliest known sources of picric acid, a yield of 50 per cent. of which was said to have been obtained by treating the resin with strong nitric acid. As picric acid is one of the most widely used of modern war explosives, and was also used formerly to some extent as a dyestuff, an impression has arisen that the resin was being used for picric acid manufacture. Whether this was so or not it is impossible to say, but experiments seem to indicate that as a

raw material for picric acid the resin would hardly be a commercial success, in view of the abundance of more suitable materials. Dissolved in methylated spirit the resin gives a spirit varnish of a deep orange-red colour, and it is also said to find considerable application in England in the manufacture of linoleum. The core and leaves of the grass tree are further believed to be useful in the production of pulp for paper-making, though it is found somewhat difficult to bleach.

INCREASED USE OF CUNAO OR CHINESE GAMBIER.

There was an increased trade in cunao or Chinese gambier in South China during 1916; the volume of the trade in this product in Hong-Kong alone is nearly 30,000 short tons (of 2,000 lb.) annually. The product is one of great value, and merits the attention of dyers. It has been used by the Chinese for many generations for dye and preservative purposes, and, since the disappearance of aniline dyes from the Chinese market as a result of the war, it is coming into still more general use. The dye is the product of crushing and soaking the root of a plant known by the Chinese as "cunao," and drawing off and concentrating the liquor therefrom.

According to a report by the United States Consul-General in Hong-Kong, there are two qualities of the product reaching the Hong-Kong market for Canton and other ports, one of which is the product of Kwangsi and Yünnan Provinces, coming largely from Lungchow and Luk Po in Kwangsi, and from Mengtse and Yünnan-fu in Yünnan Province. It is obtained in large quantities and good quality from the hills bordering the Red River in Yünnan and Kwangsi Provinces. The other quality is the product of Indo-China and certain other parts of Yünnan Province. Usually the Indo-Chinese product is employed for the first dyeing of a cloth or for the coarser work in other lines, while the Chinese product is used for the second or finishing dye, because of the deep, rich brown gloss it gives cloth.

The dye is of a brown colour, is highly astringent, works well with various mordants, and is used extensively by the Chinese for dyeing both silk and cotton, a certain class of silk dyed with it being one of the standard cloths of South China. The coarser quality is also the chief component part of a mixture applied to fishing-nets, sails, and similar fabrics to prevent rot. The product seems to have all the merits of gambier, and in general is much cheaper.

It is handled in China and in the export trade to near-by countries as a paste, and is said to lose its finer qualities if kept too long. Apparently, however, there is no reason why the product cannot be further concentrated, and, if properly packed, ought to keep indefinitely. In its moist condition, as sold in the Hong-Kong markets, it costs about 1*d.* per lb., although at times recently the price has advanced to as much as 1½*d.* per lb. With more modern treatment of the product itself, and with more scientific packing than is usually given it by the Chinese, there seems no reason why it should not be successfully introduced into other countries.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

Nettle-fibre.—A collection of the available published accounts makes the prospects of the nettle-fibre industry none too brilliant. First it is needful to get one's stinging nettles and plant them out singly, and both the planting and harvesting require labour at the same time as do the more valuable crops. When harvested there is a yield from wild nettles of about 10, and from cultivated nettles of up to 30 per cent. of bast fibre. The fibre is prepared, according to a Vienna method, by first steeping and then roasting the stems, when a fibre suitable for cordage and jute-spinning is recovered. Upon a Danish system the nettles are cut and stacked for the winter, their tops and leaves are removed, and retting is done either in a pond or in four days' immersion in hot water. The stalks are dried, broken, scutched and hackled, and by this system also a cordage and sacking fibre has been obtained. Promises of better results are held forth, but as to these there is no need to be too sanguine. Better results can, doubtless, be got also from plants which are no more difficult to raise and decidedly easier to work. If one were to reason from the analogy of ramie (or stingless nettle) there are probably a score of points upon which reassurance would be sought before accepting the success of the stinging nettle as granted. As all textile fabrics in enemy use are collected from the battlefields and subjected to examination in British laboratories, the conspicuous success of any new improvisation would soon make itself known. Nettle-fibre sand-bags and cap and coat linings have been identified, and use of the article in shirts and towels is at least suspected.

Intellectual Status.—It would be interesting to know precisely what the Departmental Committee on Textile Trades had in mind in suggesting that "staffs of British firms often occupy a lower intellectual place than their foreign competitors." To deal first with the facts, it is scarcely to be disputed that the rank-and-file of the mill are drawn from the least educated section of the surrounding community, and no very high education is needed to make one tower above the rest, and so qualify for what can be called a staff appointment. In the offices and warehouses of the trade no distinctly intellectual endowment is demanded, and when found there is not necessarily rewarded more highly than in other commercial quarters, where energy is the quality in most demand. It would be highly ungracious not to

allow for these exceptions which stultify generalisations based upon averages, but it can doubtless be maintained that, whether in the industry or the trades, no great intellectual standing is required to cause one to emerge from the ruck. If this be so, what is the reason? According to the Committee, the apathy of individual employers about the advantages of a highly specialised education. An alternative and not less available explanation would be the failure to require all-round a fuller degree of general education. Some progress has been made towards making the textile trade a career for well-educated men, and it may be believed that the work will tend to grow more interesting to them as time passes, and as new learning is applied to it. There are, for example, individuals who have thought it much more interesting to be an engineer, dealing with varied problems, than to settle down to manufacturers' routine.

Water Power.—If further instances were wanted to illustrate the influence of water power in determining the distribution of textile industry, some few might be added to the citations in Mr. Alexander Newlands' paper to the Society. Arkwright, after a beginning in Nottingham, set up his water-frame machines at Cromford to take advantage of the swifter river. "The able stream with a constant supply of water" led the Lombes to Derby, where the forerunner of all English textile factories was founded. The water was wanted in these cases for power, but not less essential to textile industry is water for washing, and it is manifest that the quantity and quality of water available for scouring, dyeing and bleaching have had great influence in the choice of sites. The water-wheel, as a source of power, is extant in remote textile districts, notably in Wales and in the Isle of Man. A water turbine in the Wharfe drives one of the most considerable worsted mills. Remains of water-driven mills are encountered in the West Riding valleys, from which, however, many have made a remarkably clean disappearance. Men not absolutely old recall in one short and pretty valley six wheels, of which no vestige can be found to-day. The historical evidence hardly supports Mr. Pratt in his supposition that British textile industry began upon the eastern edge of England, or that it was originally established by refugees. There was, however, about a hundred years ago, a notable transference of the worsted industry from East Anglia to Yorkshire. The occurrence coincided with the advent of spinning machines, which were driven principally by water-power. The new industrial North knocked Norwich and its cumbersome methods quickly out of competition.

Raw Supplies.—A more acute anxiety in finding tonnage now threatens the peace of mind of textile exporters. It is worth observing that the value of exported textile manufactures last year was approximately £17½ millions, or more than 50 per cent. higher than the £11 millions of 1915. The increase is, of course, one of prices, and when a comparison is made of the quantities of raw materials imported in the same years the facts of the position are more apparent. Of raw cotton the imports of 1917 were 51 per cent. of those of 1915; of wool 67 per cent.; of flax, hemp, and jute 50 per cent.; and of silk 87 per cent. It can be added that there are prospects of further decrease, inconvenient as it must be, and reluctant as some traders are to admit the necessity. As in the depletion of the labour supply, so in the curtailment of import and export trading the difficulties grow in complexity the further the inroads are driven. All manufacturers have not had the opportunity of sheltering under the Government umbrella, but those who have exercised an option to take Government work in preference to private orders can hardly be regretting their decision.

OBITUARY.

THOMAS TYRER.—Mr. Thomas Tyrer died suddenly on February 20th, at the age of seventy-five. He was educated at the Royal College of Science, and in 1862 was appointed works chemist to Messrs. May and Baker, manufacturers of fine chemicals, subsequently becoming managing director of the firm. For the past eighteen years he controlled the well-known works at Stratford which bear his name. Mr. Tyrer was very closely associated with the Society of Chemical Industry, and served on its council during the greater part of its existence. He was on the governing board, and on the executive, of the National Physical Laboratory, and a member of the council of the Association of British Chemical Manufacturers. He was also one of the first members of the old London School Board. He took a very active part in the efforts to secure relief from the duty on alcohol for use in arts and manufactures, and in 1904 he read a paper on this subject before the Royal Society of Arts, for which he received a silver medal. He was elected a Fellow of the Society in 1914.

GENERAL NOTES.

BRITISH FLAX.—The President of the Board of Trade has appointed a Committee "to investigate in all its bearings the question of increasing the supply of flax in the British Empire." The Chairman of the Committee is Lord Colwyn (formerly Sir Frederick Henry Smith, Bt., indiarubber and cotton manufacturer), and the Vice-Chairman Sir Frank Warner, K.B.E. (President of the Silk Association and a member of the Council of the Royal Society of Arts). The other members of the Committee are Sir Thomas Mackenzie, K.C.M.G., and Messrs. W. N. Bease, J. R. Campbell, R. G.

Campbell, Andrew Fisher, W. L. Griffith, P. C. Lyon, C.S.I., T. H. Middleton, C.B., J. R. W. Robinson, and E. F. L. Winter. The Secretary of the Committee is Mr. John A. Todd, B.L., Professor of Economics, University College, Nottingham, who, it will be remembered, read a valuable paper before the Indian Section of the Society last session on "The World's Cotton Supply and India's Share in it." The address of the Committee is Gwydyr House, Whitehall, S.W. (1)

Henry Saxon Snell Prize.—The Henry Saxon Snell Prize, which was founded to encourage improvements in the construction or adaptation of sanitary appliances, will be awarded by the Council of the Royal Sanitary Institute in 1918. It will consist of fifty guineas and the medal of the Institute, and is offered for an essay on "Suggestions for Improvements in Apparatus and Appliances for Dealing with House Refuse." Particulars of the competition may be obtained from the Secretary of the Institute, 90, Buckingham Palace Road, S.W. (1)

East African Beeswax.—Beeswax has recently formed an important article of export from East Africa, the latest market quotations putting it at £8 15*s*. to £9 15*s*. per ton. Apiculture is, however, an industry which has been much neglected, says *South Africa*, being confined to the European settlers on the high lands, a part of the country most suitably adapted for the industry. There are two rainy seasons, no winters, and very little sickness among the bees. Encouragement is being given by the Government to those who have a fancy for apiculture, and it is believed that in the near future the industry will be substantially developed. At the present time the gathering of the beeswax is almost entirely in the hands of the natives.

Rumanian Petroleum.—It was recently stated by a German authority on oil that the fuel value of Rumanian petroleum is very high, viz., 11,000 calories per kilogramme, as against 8,000 for the best Welsh coal. Germany has hitherto obtained oil from Austria-Hungary, which in 1913 produced well over 1,000,000 tons of the crude product. The *Motor* suggests that Germany anticipates an enormous development of the Diesel engine, and it may be expected that Germany will get hold of all the oil sources she can, so as to be independent of coaling-stations. An 8,000-ton ship with Diesel engines can make the trips to Japan and back on 700 tons only.

Liquid Fuel in the War.—Liquid fuel is used now for the forging of shells in the chemical industries, and, owing to the air raids and the danger involved when coal is used, works of special importance to the Government are equipped to burn by-products, such as tar, creosote, and other liquid fuels that, prior to the war, had no special value, and claimed no proper attention from the producers.—*The Shipping World.*

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

March 13.—Paul Lambotte, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, "Ypres and other Flemish Cities before and since the War." [The paper, which will be given in English, will be illustrated by numerous lantern-slides from unpublished official photographs.] The Archbishop of Canterbury will preside.

March 20.—Percy Shuttlewood, Ministry of Food, "The Food Situation in Germany."

April 10.—W. Lawrence Balls, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry." Professor William Bateson, D.Sc., F.R.S., will preside.

April 17.—Frank Stuart Courtney, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." Sir John Snell, M.Inst.C.E., will preside.

April 24.—Major Sir Robert Armstrong Jones, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons." The Right Hon. Lord Sydenham, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

May 1.—George Martineau, C.B., "Sugar from several Points of View."

May 8.—John B. Farmer, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

May 15.—Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

May 29.—Martin O. Forster, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." Sir William A. Tilden, D.Sc., LL.D., F.R.S., will preside.

Indian Section.

Thursday afternoons, at 4.30 p.m.:—

March 14.—William Foster, C.I.E., "English Commerce with India, 1608–1658." The Right Hon. J. Austen Chamberlain, M.P., will preside.

April 18.—Alfred Dickinson, M.Inst.C.E., "Water Power in India."

May 30.—Hon. Sir Dinshaw E. Wacha, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Colonial Section.

Tuesday afternoon, at 4.30 p.m.:—

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana."

Cantor Lectures.

Monday evenings, at 8 p.m.:—

J. Young, A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22. At 8 p.m.

Cobb Lectures.

Professor Henry R. Procter, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 11...Brewing, Institute of (London Section), at the Imperial Hotel, Russell-square, W.C., 7.30 p.m. Drs. Arthur Harden and S. S. Zilva, "The Anti-Beri-beri and Anti-Scurvy Accessory Substances in Beer."

Geographical Society, Burlington-gardens, W., 8.30 p.m. Mr. R. Farrer, "My Second Year's Journey in Kansu."

Electrical Engineers, Institution of (Western Local Section), Merchant Venturers' Technical College, Bristol, 5 p.m. Mr. E. B. Wedmore, "The Control of Large Amounts of Power."

Tuesday, March 12...Sociological Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. The Right Hon. J. M. Robertson, M.P., "The Idea of Race Psychology."

British Decorators, Institute of, Painters' Hall, Little Trinity-lane, E.C., 6.30 p.m. Mr. F. Dakin, "The Decoration of a Town House."

Asiatic Society, 22, Albemarle-street, W., 4 p.m. Professor D. S. Margoliouth, "Some Sources of the Arabian Nights."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. L. Hill, "The Stifling of Children's Health." (Lecture I.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Professor J. C. McLellan, "Exhibition of Cinematograph Films illustrating Water-power Works in Canada."

Anthropological Institute, 50, Great Russell-street, W.C. (Joint Meeting with the Prehistoric Society of East Anglia), 3 p.m. Mr. R. A. Smith, "Our Neighbours of the Neolithic Period." 5.15 p.m. 1. Mr. H. J. E. Peake, "The Age of some Megalithic Structures in the Mediterranean Area." 2. Mr. A. L. Lewis, "Exhibition of Flint Implements, etc., found on the surface in Beddington, Carshalton and Wallington, Surrey."

Electrical Engineers, Institution of (Scottish Section), Princes-street Station Hotel, Edinburgh, 7 p.m. Mr. C. M. Jacobs, "Electrical Signalling and Control on Railways."

(Yorkshire Section.) Philosophical Hall, Leeds, 7 p.m. Dr. S. F. Barclay, "The Mechanical Design and Specification of the Turbo-Alternator Rotor."

(Manchester Section.) 17, Albert-square, Manchester, 7 p.m. Mr. E. B. Wedmore, "The Control of Large Amounts of Power."

Wednesday, March 13...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. M. Paul Lambotte, "Ypres and other Flemish Cities before and since the War."

Automobile Engineers, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m. Mr. F. L. Martineau, "Nomography, with a few references to its use in Engine Design."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor W. H. Thompson, "Food in its relation to External or Useful Work."

Colonial Institute, Caxton Hall, Westminster, S.W., 8.30 p.m.

Metals, Institute of, at the Chemical Society, Burlington House, W., 8 p.m. Annual General Meeting. Presidential Address by Professor Carpenter.

British Acetylene and Welding Association, Holborn Restaurant, W.C., 2.30 p.m. Captain D. Richardson, "Notes on defective Oxy-Acetylene Welds."

Japan Society, 20, Hanover-square, W., 3.30 p.m. Mr. W. Gadow, "Glimpses of Old Korea."

Thursday, March 14...Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. W. Foster, "English Commerce with India, 1608–1658."

Aëronautical Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Metals, Institute of, at the Chemical Society, Burlington House, W., 4 p.m. 1. Mr. J. N. Greenwood, "The Relationship between Hardness and Constitution in the Copper rich Aluminium-Copper Alloys." 2. Messrs. H. Whitaker and H. Rix, "Aluminium Bronze Die Casting." 3. Dr. G. H. Gulliver, "On Grain Size." 4. Mr. O. W. Ellis, "Lead-Tin-Antimony Alloys."

8 p.m. 1. Professor H. C. H. Carpenter and Miss C. F. Elam, "An Investigation on Unsound Castings of Admiralty Bronze (88 : 10 : 2): Its Cause and the Remedy." 2. Kinematographic Exhibition, "Canadian Water Power."

Royal Institution, Albemarle-street, W., 3 p.m. Sir Alexander Mackenzie, "War Music: Past and Present." (Lecture II.)

Camera Club, 17, John-street, Adelphi, W.C., 8.15 p.m. Mr. F. J. Mortimer, "War Time Printing Processes."

Historical Society, 22, Russell-square, W.C., 5 p.m. Mr. E. Lipson, "The Evolution of Capitalism in the Woollen Industry."

Optical Society, Imperial College of Science and Technology, South Kensington, 8 p.m. 1. Naval Instructor T. Y. Baker, "Reflecting Prisms." 2. Mr. T. Smith, "The Detection of 'Ghosts' in Prisms."

Paint and Varnish Society, St. Bride Institute, Bride-lane, E.C., 6.30 p.m. Discussion on "The Paint and Varnish Trades under existing Restrictions."

Friday, March 15...Royal Institution, Albemarle-street, W., 5.30 p.m. Right Rev. W. Boyd-Carpenter, "The Romantic Movement."

University of London, Slade School of Fine Art, University College, W.C., 4.30 p.m. Dr. T. Borenius, "Sixteenth and Seventeenth Century Art." (Lecture IX.)

Mechanical Engineers, Institution of, Storey's-gate, Westminster, S.W., 6 p.m.

Saturday, March 16...Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. J. Thomson, "Problems in Atomic Structure." (Lecture V.)

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

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FRIDAY, MARCH 15, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 20th, at 4.30 p.m. (Ordinary Meeting.) PERCY SHUTTLEWOOD, Ministry of Food, "The Food Situation in Germany."

Further particulars of the Society's meetings were published in the last issue of the *Journal*.

COUNCIL.

At the last meeting of the Council, on Monday, the 11th inst., Lord Leverhulme was elected a member of the Council and Vice-President of the Society, in place of the late Sir John Wolfe-Barry, K.C.B., F.R.S.

"TRUEMAN WOOD" LECTURE ENDOWMENT FUND.

On the resignation of the Secretaryship by Sir Henry Trueman Wood in 1917, the Council resolved to institute an annual "Trueman Wood" Lecture to commemorate the services rendered to the Society by Sir Henry during the thirty-eight years for which he had held office. In order to place the lecture on a secure and permanent basis, by providing a substantial yearly fee for the lecture, it was subsequently decided to invite past and present members of the Council to raise an endowment fund. In response to a notice circulated among them, the sum of £643 has now been subscribed.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1918 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 23rd, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce."

The list of those who have received it since its institution in 1864 was given in the last number of the *Journal*.

FOURTEENTH ORDINARY MEETING.

Wednesday afternoon, March 13th; HIS GRACE THE ARCHBISHOP OF CANTERBURY in the chair. A paper on "Ypres and other Flemish Cities before and since the War" was read by M. PAUL LAMBOTTE, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique.

The paper and discussion will be published in the *Journal* of April 12th.

INDIAN SECTION.

Thursday afternoon, March 14th; The RIGHT HON. J. AUSTEN CHAMBERLAIN, M.P., in the chair. A paper on "English Commerce with India, 1608–1658" was read by Mr. WILLIAM FOSTER, C.I.E.

The paper and discussion will be published in the *Journal* of April 19th.

COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers will be supplied, post free, for 2*s.* each, on application to the Secretary.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and can be obtained by Fellows on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

Wednesday, February 20th, 1918; John Slater, F.R.I.B.A., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Brocklebank, Rev. Clement Edmund Royds, London.
Drummond, George Henry, London.
Hobson, Arthur E., Connecticut, U.S.A.
Jou-lin, President Tsao, Pekin, China.
Leverhulme, Lord, London.
Marshall, Herbert J., Gainsborough.
Metcalf, Henry E., London.
Mortimer, Engineer-Commander John Ernest, R.N. (retired), M.I.N.A., M.I.Mech.E., London.
Ogden, Henry Joseph, London.
Pantin, Carl Frederick Abel, Second Lieut. R.E., London.
Pantin, Herbert, London.
Quin, Lawrence Howard, London.
Rodd, Charles, Poole, Dorset.
Stephens, Mrs., London.
White, Charles, Aberystwyth.

The following candidates were balloted for and duly elected Fellows of the Society:—

Bamber, Herbert Kelway, M.V.O., Datchet.
Campbell, Donald Fraser, London.
Galpin, Stanley M. A., Aylesbury.
Gell, John, M.I.E.E., London.
Gridley, Charles Oscar, London.
Hinchley, Professor John William, A.R.S.M., Wh.Sc., F.I.C., London.
Murdoch, J. Alfred, London.
Parkes, S. Thomas Hickling, Birmingham.

The paper read was—

SUGGESTIONS TOWARDS AN APPRECIATION OF THE PICTURESQUE CONSIDERED IN RELATION TO SOCIAL CONDITIONS AND ENVIRONMENT.

By Maurice B. Adams, F.R.I.B.A.

We are told that "the ancient homes of the people survive as sepulchres of the dead." This comment is not only incomplete, but most misleading. My object is to awaken an interest and not to promote a wordy argument, much less to premise a shibboleth. The title chosen for this paper is said to be too long, and others complain that the wording is obscure. Perhaps the confusion about our title may have arisen from a misapprehension as to what the word "picturesque" really means. The term is generally misused, and it is, of course, not exactly an equivalent to "pictorial." Certainly in its application to buildings or sculpture it implies much more, and cannot be limited to pictorial compositions set out on one picture field as in a drawing or painting. Picturesqueness is a relative quality, and De Quincey somewhere asked, "What is picturesque in relation to the beautiful and the sublime?" Sir Joshua Reynolds furnished an answer when he described a series of crosses as being "placed prospectively in an uncommonly picturesque manner."

This prospectivity of arrangement, architecturally speaking, comprehends the effect of a structure on all its sides, and judges the work likewise as to its particular purpose, its position on the site, and whether it must commonly be seen from above or from below. Accidents and decay may add to the picturesque, it is true, but we are treating of buildings, not ruins. The relation of a building to its environment is of great moment. A bleak and rocky open spot on a wild position demands a different edifice from one more suitable for a cosy coombe well sheltered by trees. The value of solids and voids comes into play; one feature governs another, thus determining the grouping and breadth of treatment. The proportions and perspective lines delineated as in a picture might exhibit a frontispiece from one point of view, but light and shade in the brilliant sunshine of June become absolutely another question during the half tones of a winter's dull day.

Thus we begin to understand the importance of skyline and profiles in silhouette and in the round. A water-colour sketch may be *chic* and effective, and yet be essentially misleading. Architecture is the mistress art, and must be more than a mere pictorial idea. She provides housing for man and beast, giving shelter for paintings, scope for sculpture, and opportunities for the arts and crafts. Architecture is not a matter of more or less stuck-on ornament. Its success and power of influence depend upon stability, form, and fitness because architecture absolutely is fundamental.

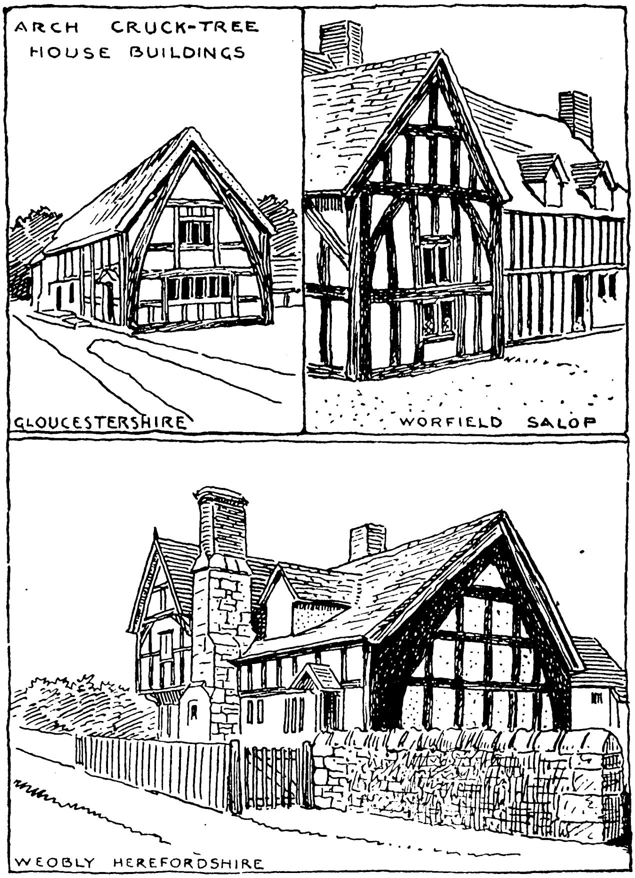
Paradoxical, however, as it may seem, one primary distinction must be admitted, and please recognise therefore the absence of any sort of presumption on the part of our old picturesque building work to rank as

architecture at all. It makes no such claim, and considered evolution in house-building in a precise periodical sense is unknown. Vernacular directness of construction and sublime simplicity made these indigenous structures what they were. All idea of preconceived quaintness was foreign to their genesis. They are not warrens of incongruous oddments or little kinks of incoherent buggaboo art and snobbishness, emulating their betters.

Such work is so primitive and so natural that it cannot nowadays be successfully repeated, and when attempts are made they result in incongruities. There was no make-believe about the builders who put them up, and therefore we glory in these delightful old cottages and rural buildings. They had no stylish notions, and what our ancestors built was spontaneous and new—therefore reasonable and pleasant. The manner adopted arose from daily needs and local materials ready to hand. The old-time housings are for all time understandable, and were inspired by individuality of character, by practical and traditional methods, thus giving the work of different countries local distinction. The craft employed was coherent, though at best, perhaps, little more than a sort of naively inspired rule of thumb without oblations of style. The beauties of British folklore, crude as old ballads or rhythms may seem, are undeniably human and devoid of the mannerisms of "polite literature." Chaucer, like Danté, employed the vulgar tongue. The spirit of the language is the most important key to the spirit of the people. The old craftsman inspired his job with the personality of individual charm, also intuitive harmony, rough in expression, but unsophisticated and native. He worked leisurely, putting his mind into his work because he enjoyed the task untrammelled by trade unions, though likely enough he belonged to a neighbouring guild of artificers. After the more primitive erections of timber gave place to stone buildings, the carpenter long occupied a very inferior position, most of the work being in the hands of masons. As a result, woodwork became illogical, inasmuch as timber construction imitated the methods peculiar to stone. For instance, when a wooden chest had to be made, a balk of oak was hollowed out like a stone coffin, or, if a wooden altar tomb was required, the carpenter employed big slabs of stuff, dowelling them together to represent stone with arcades copied from masonry and coloured to match. Sir John Pitchford's tomb, at Pitchford in Shropshire, I show so that you will see that traditional work was not always consistent in this respect. Later on, when woodwork obtained its mastery among the crafts towards the close of the fifteenth century, the carpenter turned the tables on the mason, who, in his turn, emulated the triumphs of timber by endeavouring to copy wooden detail in stone. A few facts of this fundamental kind have to be kept in mind when considering the basis of the picturesque.

Building by-laws were very few even in London during the Middle Ages. The main problem was the manner of roofing, and this influenced the shape of all buildings from remote times in all countries. The country homes of England in earlier times had no fireplaces or chimneys, and very few windows. Smoke flues eventually revolutionised, and, of course, enormously increased the picturesque outline of all dwellings, to say nothing of their comfort. The virility of the art of building, and especially the planning of houses, depended on details incidental to contemporary requirements as the counterpart of everyday customs carried out in an artless, straightforward way. The fashion, such as it was, resulted naturally in this simple manner. The worker in that sense was master of his craft, and emulation induced one good artificer to copy the better work of another, but the outcome, as a whole, was not imitative as a revived use of previous periods.

The Gothic revival of mid-Victorian days failed for that reason, though the result was an enormous success. The movement had a vital power of its own as the outcome of the Tractarian revival in Oxford. Most excellent churches have been built on Gothic revival lines, but the school of Mediævalists, like the cult of the pre-Raphaelites of yesterday, has had its day. The enterprise, however, was unique, picturesque, and inspiring. Impressionists and Cubists are to the fore meanwhile, and at present there is no common school of considered thought in architectural design. There is no lack of literary dexterity, and enterprising professors vie with each other in the use of paradoxical phrases; but all the coteries, with their disputations and conferences, cannot get over the hiatus between the present and the past owing to the elementary fact that they cannot bring back our lost traditions. New art is an absurdity, inasmuch as there are only two kinds of art—the good and the bad. The best is artless, hence the mere outwardly equipped artist or schoolman has no abiding pregnancy in spite of his technique,



of tradition. Scholarly academic productions belong entirely to another category, and when most correct and mechanically true to pattern they correspondingly fail. This lack of success arises from the absence of inventive imagination, the Divine afflatus—

> "What boots it thy virtue,
> What profit thy parts,
> While one thing thou lackest—
> The art of all arts?"

The intuitive artist cannot be fettered in that way: therefore, if he be rightly directed, precedent serves his purpose primarily as a formative medium of expression, and he takes precious good care to employ structural materials so as to preserve their relative scale of colour and natural texture. Finish and manner of jointings in all trades of building work are of extreme importance, and an artist worthy of the name has no fear whatever of making his work look new. He builds for to-day as well as for posterity, so time alone can test his work.

Local materials ought always to be locally used by old methods of handling without admixtures of foreign importations, unless a district happens to have no good materials of its own. On the banks of the Nile mud-clay stands better than ferro-concrete faced with stone ashlar. The blue slates of Wales look well enough midst the national mountain uplands, but no more ugly and hard-looking material can be used in a brick country like Sussex. The well-timbered countryside produced wood-framed houses, and where stone abounded masonry of course prevailed. Thus architecture naturally was native, forming part and parcel of the landscape.

which at first sight seems so captivating. Intuition is only hampered and stultified by erudite artifice. Creative art cannot be evolved by copying extinct styles, though, on the other hand, progress must ever depend upon a digest of what has gone before, and, provided such knowledge is stimulated by a recognition of the whys and the wherefores of historic design, development is assured. That is my reason for insisting so much upon the atmosphere surrounding the subject under our consideration, as to what actually constitutes the real character of the picturesque, not that I can hope to put forward anything new in detail. Egotists have tried to become emancipated and so, in order to become original, sought to ignore the alphabet of the arts, so the upshot of their amateurish essays failed. That sort of thing speedily tires, does not mature, cannot weather well, and being emasculated is incapable of repetition.

In judging architecture, qualifications have to be observed as to scale, cost and purpose, as well as the influence of differing materials. Workmen now have no idea whatever as to the meaning

Our inquiry begins with the Middle Ages. The troglodytes and pre-Conquest tenements or shelters of the Romany people need not detain us, though an occasion will occur for reference to the huts of old charcoal-burners of the past. The earliest wooden structures had to do with bent-tree roof construction, which obviated solid sidewalls. The "crucks," or balks of timber—hence the word rooftree—set "the wrong way up" on pieces of stone or slabs laid on the earth. In this manner the

ridges and weight of the roofings were carried independently of vertical walling. Oak, elm, ash and beech timbers were employed, but chestnut wood only rarely. Basketwork and wattle daubed with mortar or mud served for the panels of framed structures, and filled in the interspaces in lieu of walls. In Stuart days brick fillings called "nogging" came into vogue; it was very heavy and in time sagged badly. The earliest building with timber walls is the Saxon church at Greenstead near Ongar in Essex. The construction of wooden roofs reached its climax during the sixteenth century when the wright did most of the work, still using the adze for shaping and squaring the timbers, which were cut into balks by the pit saw. The plane and moulding stocks were then unknown. The adze and the chisel gave a personal finish and charm of texture or touch, as may be seen by the church screens and bench-roods in Devonshire and Suffolk. The work was not done to one dead level by the smoothing plane and sandpaper.

Oak shingles on roofs and weather boarding for walls gradually became more common, but thatch served for roofing in half the counties of England. Stone slabs were usual in the north parts of Cheshire and in Dorset. The risk of fire before engines were employed was met by erecting timber houses so unsubstantially that their frontages could be easily pulled down bodily into the road, and in the thirteenth century London aldermen and urban officials were provided with long iron crooks for this purpose. In the Moot Hall, Thaxted, Essex, a pair of such hooks can still be seen, and in other places also examples have been preserved. They were used as late as the Great Fire of London in 1666.

In order to realise in some degree the atmosphere, so to speak, of the fourteenth century, allow me to give an inventory of a specimen house of the better class of craftsman within the walls of the metropolis in 1337. My particulars are extracted from a legal indenture concerning Hugh de Bevere, who was murdered that year. The house which he occupied comprised two apartments, one above the other. The lower room had a door opening on to the street, and served as a kitchen or keeping room. It had a chimney and a fireplace. Light was obtained by one window, the upper part only being glazed and a shutter closed up the remainder. At the back of the premises stood the buttery containing six wine casks. In the living room a trestle table and two chairs were the only furniture, but there were several serviceable utensils—a grate, some hanging pots, andirons, basins, washing vessels, iron horse, cooking pot, frying pan, a funnel, and a pair of ankers or tubs. Access to the upper room or solar was obtained by a ladder through a space left open in the floor. The house was all of wood, but in accordance with the city regulations the party walls were of stone. This sleeping room contained a bed with mattress on it and three feather beds, also two pillows. A big chest or coffer stood against the wall, stored with six blankets and one serge or coverlet with shields of sendal, a kind of thin silk, eight linen sheets, and four table-cloths. Alice le Bevere, the newly-made wife and so soon a widow, looked with justified pride on the contents of her press. A candlestick of "lattone," two plates, an aumbry, and, for luxury, they had curtains to hang before the door to keep out the cold, cushions, and even a green carpet. No glass mirrors, pictures, forks, no pins, and no writing paper; also no soap, for that was little used. The development of ruffs and wide collars many years later was due to the general introduction of soap. The humbler dwellings had beds formed of a heap of straw upon which a whitel, or blanket, was spread. The floors were of earth and strewn with rushes or reeds. Parliament and the City Fathers passed stringent orders from time to time to prevent the defiling of the Thames with rushes and refuse turned out of the houses of London into the river, which was generally so bad that plagues were periodically caused.

The fragile wattle framings of the walls made of "raddle and dab" enabled thieves to gain an easy entry; hence the term "house breaking" survives. In the West of England "cob" is the dialect name of mud walling which dates from Babylonia, thousands of years ago. The Ancients ornamented their mud buildings with stone pins pressed into the clay in quite beautiful patterns, and you will notice how admirably the rounded formations suited the material, as shown by the walls of Warka, in Chaldea.

Cob cottages were both cheap and warm, as well as durable. Road-sweepings were employed in layers intermixed with the clay, or straw at times was worked in to give it a bond similarly. In London in 1189 clay was thus used, but the material cracks sufficiently to harbour bugs and pests.

During Elizabeth's reign, stone rubble foundations were used for cob cottages and thatch covered the roofs as at the present day. I show a good pair, including Cockington Forge, near

Torquay. Chalk mixed with clay will be found in cottages about Devonshire, and chalk built up in brick courses occurs in Wiltshire about the district of the great White Horse. In half-timber framed houses the wood muntins and plates projected in front of the stucco panels at first, but when, for cheapness sake, the timber was wider spaced the plastering was finished flush. This facilitated rot, and when the work began to perish the framings were rough casted all over or hung with tiles and weather boarding. Stucco is a splendid material for lasting, and is easily ornamented with fine effect as at Clare and Wyvenhoe, in Suffolk, to mention only two of many fine examples. The rough timberings left exposed inside framed houses were covered by tapestry in the dwellings of the rich as already mentioned, but in manor houses the plastered panels were sometimes papered over, and in evidence of this I give a slide from Borden Hall, Kent, with two patterns of paper fixed up with flat-headed nails and dating from 1600 to 1650. The walls in this room were battened over, and so these papers were hidden up for, say, two hundred years. These old papers were printed from small blocks as used for cotton-printing. The ornament, rather Indian in style, was in black on a vermilion ground picked out in bright turquoise blue. At Ightham Mote, in the same district, there are some Charles II. wallpapers, but it was not till the eighteenth century that paper-hangings came into general use. Originally they were made in small squares, very difficult to match when fixing the paper with nails.

William Morris was the pioneer who first improved wallpapers, and he copied his charming schemes from "Gerarde's Herbal," wherein the flowers are drawn out like pressed specimens of plant forms. His sole exception to these conventional shapes was a fruity fancy for pomegranates spread bountifully over everything in a gorgeous glamour of mediævalism.

Morris was trained as an architect under G. E. Street, and this reference to him recalls the furnishing firm which he financed and founded in association with the pre-Raphaelite brotherhood to whom the credit belongs of endeavouring to endow Western Europe in the sixties with æstheticism. Every praise is due to these enthusiasts for heightening the prestige of applied art and influencing taste among thinking people. The prevailing impression of the cult was associated with peacock's feathers, sunflowers, a rage for blue crockery, and suffused with the smell of the virgin lily. In actual life William Morris and his friends were by no means lily-like or actually so ascetic as is supposed. They were reactionary and anti-scientific, and, like dukes and bishops, were machine haters, science haters, rule-of-thumbites to the bone. They promulgated Fabian Socialism as a protest against commercialism, also the condition of taste brought about by the 1851 Exhibition and Manchester prosperity. None the less, these emancipators recognised that their professional programme had money in it.

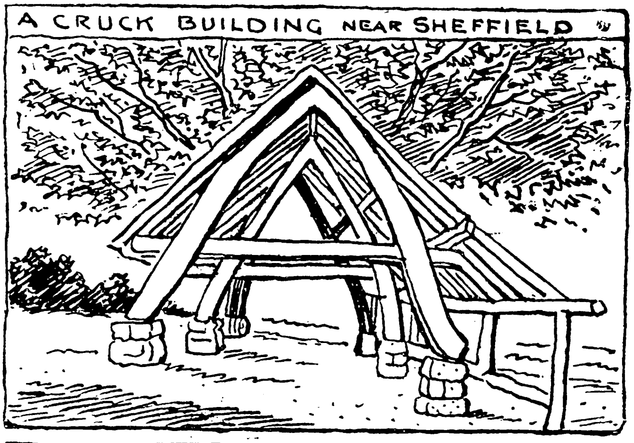
Stone houses do not appear to have proved much more durable than those built of other materials, though we see more of them as they were in the aggregate more numerous. After the Reformation, when agriculture lost the support of the church and ruined monasteries, a great many dwellings of all sorts fell into a bad way and perished. The development of roads led to stone wallings being used as quarries for making highways. Built of unjointed rubble mostly, the work was easily pulled down. If you examine this old masonry you will observe that the old builders in a natural way put the bigger blocks at the base, and gradually diminished the sizes till the top courses were reached. The quoins and jamb stones to the openings being random-shaped tailed into the rubble. All this simple contrivance gave much picturesqueness, and in the thirteenth century a sense of scale obtained by employing small blocks of stone with countless wide joints then the rule. When, however, Gothic work ran to seed, two centuries later, big stones and fine joints diminished interest, and the effect of proportion was lost. Stone slabs and slates for covering roofs were also laid in diminishing courses from eaves to ridge.

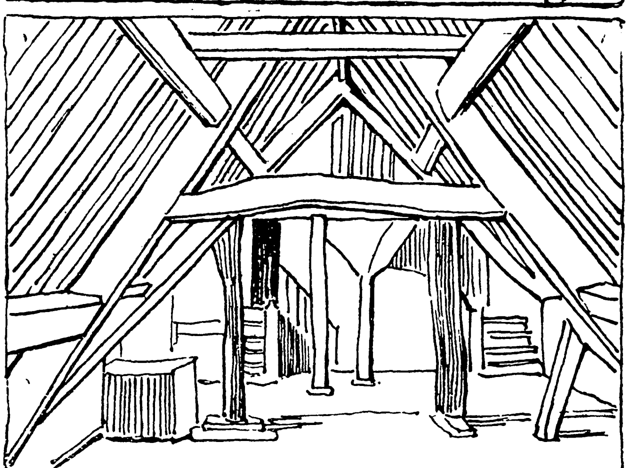
Mortar of mud remained in common use till the beginning of the nineteenth century, when lime mortar for better-class construction prevailed. Wide mortar joints garnetted with flint chips, after the manner already spoken of in Chaldea, can be seen in various old hamlets, as in Surrey villages. The origin of brickwork in England is obscure. Two very early instances of distinctive brickwork are Caister Castle and Little Wenham Hall in Suffolk, but probably the bricks came from abroad. Sussex vernacular brick quoins to flint wallings make a countrified and suitable job. Snapped flint and flint rubble made most durable and beautiful walls, specially in East Anglia, where it was rich. Colleges, churches, and houses had earth floors. These floors freely absorbed nitrous matter, and not infrequently bones were hammered in

to add geometric patterns, and also to harden the surface. This practice lasted till the end of Queen Anne's reign. For many years prior to that officials, called "saltpetre men," invaded buildings to dig up the earth floors in order to obtain nitre for making gunpowder from the floors of cowsheds, stables, and country houses. Bullocks' blood at this time was used mixed with the earth to harden the surface of mud flooring, take a polish, and prevent dust. Soot mixed with blood also served as a paint for colouring the inside timbering of dwellings. The first joist and wooden framed floors were used in Norman castles with cross-beams, from whence developed the familiar practice of oversailing the upper stories of domestic buildings. Thick planks and solid wood stair-treads were at first the rule, but as timber got scarcer thin boards and built-up stairs came in. Ordinary dwellings prior to the fifteenth century were seldom built more than two floors high. Staircases were rare; consequently the commonalty clambered up to bed by way of ladders or by means of pegs projecting from a central post, and these pegs gave a hold for feet and hands. The description of the London house previously quoted is a case in point. Staircases in the seventeenth-century yeoman's house and farmstead dwellings were often contrived in an awkward fashion, mostly cramped in by the side of recessed open fireplaces, and unequally built with odd-shaped winders and pinched in quarter landings set around the flue which also, quite likely, was an addition. The floors varied a good deal, and now and again very little headroom was allowed. Four-post bedsteads with heavy hangings were a necessity to keep out the wind, for these rooms were very draughty, though distinctly picturesque. Straight stairways sometimes were put under pents outside and considered sufficient, for our ancestors lived most times very much out of doors. A delightfully quaint outside stair is exhibited from Denham. In Jacobean days dog-legged staircases in short flights, with massive newels and quarter spaces or half landings furnished the favourite method in better-class houses. In historic houses stairs were very narrow and low, so big pieces of furniture were reckoned as belonging to the premises and formed part of the tenancy. No doubt it must have been very difficult to engineer coffins down most of these old, quaint staircases. This trouble is amusingly exemplified by the story told in "My Own Times" by Lady Dorothy Neville. A doctor advised an elderly lady, who much needed a change, to take rooms in an old farmhouse with which he was familiar and situated in an exceedingly healthy part of the country. His patient accordingly visited the place to make arrangements, and before leaving, having noticed the damaged staircase, said to the farmer's wife, "Before I come to stay with you the missing balusters must be made good for the stairs look so dangerous." The good woman replied: "Madam, that would be a needless expense to put us to, as the undertaker's men would only knock the balusters out again when bringing down the coffins."

The introduction of fireplaces was a revolution. For ages the smoke from smouldering embers of peat or wood was left to filter through the thatch of the roof or escape, if it could, under the eaves or get away through the gable hole which was provided as a vent fitted with a stone slab worked on a vertical pivot to shut up in bad weather. The lingering smoke thus oozed out gradually and deodorised the interiors. Sweet herbs were scattered over the floors of old churches and houses, but at best could have afforded only a temporary disguise to more pungent odours. Chimneys were gradually built to old houses, but even so palatial a mansion as Penshurst Place, Kent, still retains its brazier set in the centre of its magnificent hall floor The smoke has to get away through the louvres of the open-timbered roof big turret. Such picturesque discomforts do not seem to have troubled our forefathers, who survived many disagreeable inconveniences. Chimneys greatly modified the style of house-planning, and stately ideas, suggesting balance of parts, owe much to their introduction. Interiors gained by the importance accorded to the chimney-piece, and almost each generation added to their display and comfort. Chimneys in Tudor days grew to be highly ornamental, grouped together in a dignified way, diversified with weatherings and set-offs, often foliated or carved into diapered patterns. East Barsham Hall in Norfolk, Hornham Hall, Essex, and Huddington Court, Worcester, occur to the mind as specimens, as at Hampton Court. Parapets, as well as corbelled bay windows and chimney corner projections made also highly-pleasing features. Cottages had wide, oversailing eaves as the chief opportunity for effect with a deep shadow between the roofing and the walls. This is of essential value because it emphasises the horizontal lines which must prevail in elementary forms of domestic architecture. The overhanging of upper floors, which always looks

so picturesque, also kept the walling below very dry and gave a needed shelter. Small buildings, to be effective, ought to be handled as the old ones were in a big way, avoiding vertical lines because they cut up broad composition. The heavy eaves, on the other hand, give the effect of size and serve the practical purpose of throwing the roof water away from the walling. Guttering, even in town houses, was scarcely ever used. In the Middle Ages thatch had to be limewashed according to law as retarding fire and germination of "thatch fleas." The methods adopted to weight down and firmly fix the thatch added greatly to its delightful appearance





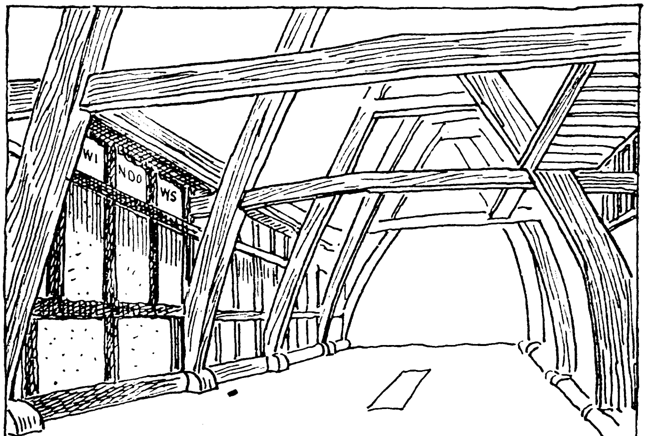
Doorways in many places were low and small, being made primarily with a view to defence more than convenience. Often enough in Stuart times the doors scaled no more than 4 ft. 6 in. high. The "heck" or "hatch" door, made in two heights, hung to open outwards independently of each other, was quite common, and the top half was of open lattice to admit light because windows were not often provided in the older cottages. The mullioned windows of the thirteenth-century dwellings were fitted with running shutters in superior cases. Lead cames followed only when glass became available. Oiled canvas served in the absence of glass, and the Chapter House windows of Westminster Abbey, as late as 1253, were treated in this manner.

Sash windows became the vogue in the time of the Commonwealth, but to save expense many were not made to open, and later on sham windows to ensure a uniform integrity of fenestration were adopted. This had the sanction of Sir Christopher Wren, as in his grand additions and Fountain Court at Hampton Court erected for William of Orange. The window tax shut up a vast number, and to this day the industrial classes have a decided objection to fresh air even in garden cities. There was no water-supply in old-time houses other than wells; and baths, as fixtures, belong to our own day. When Grosvenor Square was built few of the big mansions had proper bathrooms.

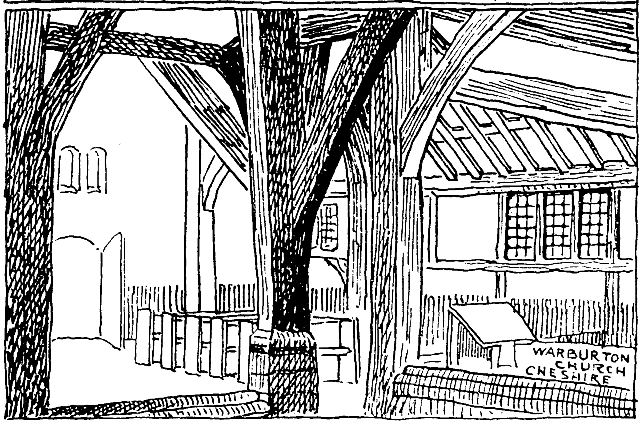
Reverting to the simplicity of the scheme of cruck timber framing, I wish to show how the method subsequently developed, and we have already seen a charcoal-burners' hut near Sheffield, for which I am indebted to Mr. C. F. Innocent, as also for several other details about the cruck method of building, and the history of this subject of timber work as described in his book on "The Development of English Building Construction."* I show also the top story of a fifteenth-century dwelling at Abingdon, a sketch of the attic of Kelmscott Manor, William Morris's Surrey house, a drawing of one of the aisles of Leominster church near Arundel, and the interior of Warbarton church, Cheshire, all in timber. The last is like the barn in the same county at Arley. Finer still is the Grange Barn at Alciston, Sussex, with its almost cathedral-like effect.

* Cambridge University Press, 1917. 10s. 6d.

The proportions of house roofs long continued to be of vast size in one span, thereby ensuring distinction of scale and ample room for storing, every house having to be self-reliant for supplies. In historic domestic buildings long low lines prevailed, and the height of pitch from floor to ceiling was seldom more than sufficient to stand upright in. Very few old dwellings had communicating passages, one apartment leading haphazard into another. People paid no attention to personal retirement, and the sexes were not particular about privacy. The floor boards and joists of the upper apartments in such places were left exposed, and the unplastered ceilings allowed the dust from above to drop through the flooring, while every movement was audible from below. The kitchen, or keeping place, invariably formed the chief room for the household use. Wash and brewhouses were ample and adjacent. Big brick ovens projected in a picturesque fashion externally alongside the added chimney corners.

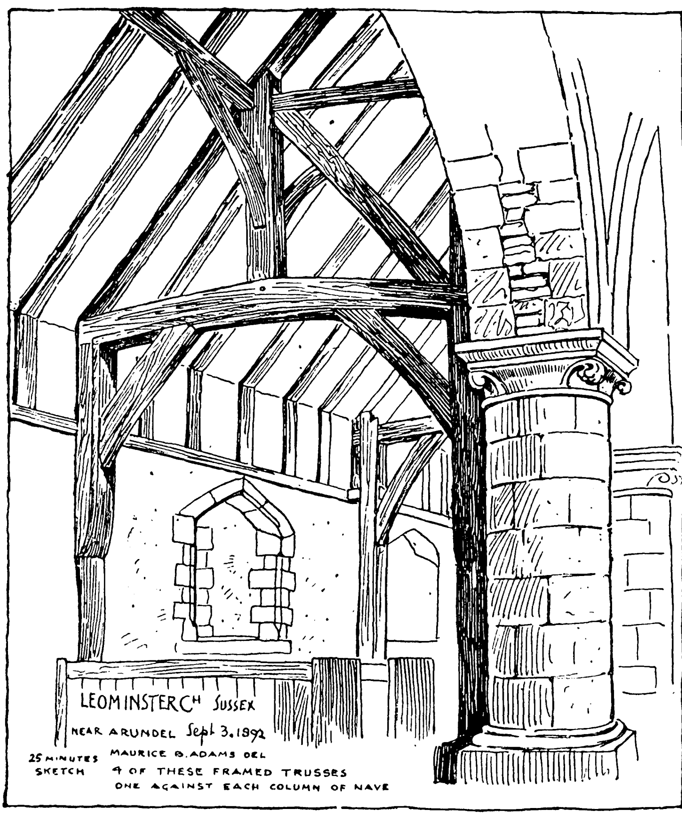


CRUCK ROOFING, ARLEY OLD BARN, CHESHIRE



Early in the last century the older folk resisted the provision of regular meal or dining-rooms as a new-fangled notion, and as for ablutions of the body, such a practice was thought necessary only for "dirty people." Sea bathing was, in fact, ignored till George, then Prince Regent, made Brighton fashionable by erecting the Royal Pavilion, and Mother Gunn supplied the bathing machines. Sanitary conveniences were not considered. The term did not occur in their vocabulary, so you will look in vain for the word in old dictionaries. Drainage remained dangerous and inefficient for many years after Victoria came to the throne. The basement of Eton College Chapel one hundred years ago formed a big sewage tank, with sluices opened once a week to allow backwater from a tributary of the Thames to act as a sort of inefficient flush, and this was the only outlet for the filth collected from the college buildings. The comely houses of Queen Anne, and the formal dignity of Georgian homes, ignored proper amenities in this matter. Prospect even was reckoned of little account before the coming of Dutch William, when only the best houses were placed with reference to the available view. Many things which we take as a matter of course were undreamt of in the fifteenth century, when the stately creations of the Renaissance flourished on the Continent in all their grandeur, when men of letters, giants of politics and geographical discovery, abounded, when Michael Angelo and Benvenuto Cellini excelled in fame. No retrospective glance at the picturesque broadly considered, would be adequate without a passing reference to those brilliant times, but probably never a period existed of more extreme depravity, the age of poison and the dagger. Men and women broke the Ten Commandments well, and counterbalanced affairs by doing beautiful work equally well. Beauty was rigidly relegated by the Puritans of the Commonwealth, though shocking things were done with an air of sanctity. Extravagances continued, as recorded by Pepys, in Stuart times and during the Dutch wars. These practices

flourished under William of Orange when Sir Christopher Wren built that king's noble wing to Hampton Court Palace. Passing on, we reach the four Georges, and in this excursion we fall in company with our great satirist and painter William Hogarth, and we meet the less known George Crabbe of Aldeburgh, whom Lord Byron described as "nature's sternest painter and first poet of his time." These worthies with masterly humour painted with graphic vividness many amusing though terribly sordid doings in high life, as well as below stairs. Hogarth's grim realisms, in his pictures of "Beer Street" and "Gin Lane," give an idea of public depravity which prevailed under Protestant rule after the failure of the notorious "Gin Act," when retailers did a roaring trade and advertised on signboards outside their shops inviting folks "to be drunk for a penny, dead drunk for twopence, or have a suck of Holland's through a straw for nothing." "The Reminiscences of Cambridge," by Henry Cunning, presents an intimate notion of morals and undeniably gross conduct which obtained in our universities of learning towards the end of the eighteenth century, when churchmen behaved very badly. Considering the deplorable standard of social life at this time throughout Europe, such a climax need perhaps cause little surprise. Pews and "three deckers" in churches may have been picturesque, and incumbencies were treated as privileged freeholds. The pews owned by the rich were furnished like parlours to doze in, and the poor were relegated to "free seats." Before "the Reformation," mural stone benches in church aisles were used by the sick and aged, hence the saying "the weakest go to the wall." No doubt in the fourteenth century many churches were furnished with elaborate stalls and benches, particularly in the west of England and East Anglia. A few admirable Jacobean examples, the forerunners of pew boxes of later days, may also be quoted, and very picturesque they are. Rolandson and Gilray, by their cartoons and coloured prints, leave no doubt about the flavour of affairs both in the Church and State. Wit was then ingenerate, sarcasm pungent, and humour bawdy. The story of "The Four Georges," by Thackeray, bears witness, and to carry on further we recall the characters depicted by Charles Dickens, whose account of Marshalsea, the Fleet and Newgate Prisons are not forgotten, in company with Fagin, the picturesque practitioner Pecksniff, and Bumbledom, when workhouses furnished a landmark as a dire blot on our landscapes. This brief review will suffice to exhibit how desirable it is, in considering our architectural studies, to redress prevailing ideas concerning the relative conditions distinguishing periods of British manners both before and after the Reformation.



Much of the beautiful work already described belonged to the so-termed "Dark Ages": therefore, to appreciate the influence which inspired it, we must look fairly in the face outstanding facts and bring into account some things which, taken apart on their merits, might at first sight seem to be outside the limits of this subject. All that concerns humanities,

however, does intimately matter as to their homes. To be practical, we cannot afford to ignore the best evidence obtainable: consequently with your forbearance it will be germane in this regard to give a few figures before concluding our brief summary of the normal affairs of our ancestors, and the circumstance during the ages when these picturesque houses and little hamlet churches were built. I am anxious to avoid carefully authorities influenced by ecclesiastical predilections, and I therefore have chosen William Cobbett, who certainly cannot, with any degree of truth, be suspected of any such partiality or limitations. When he wrote the following particulars, he was correctly reckoned an authority and considerable spokesman on the land question when Churchmanship was at a discount. These are his words: "The general idea is that before Protestant times England was comparatively insignificant, having few people in it, and those few wretchedly poor and miserable. Whereas all the parishes about the land are still in point of size what they were a thousand years ago, except where they have been united, and two or three or four even have been made into one. The County of Norfolk is the best cultivated of any one in England. In 1830 Norfolk had 731 parishes, and formerly the number was greater. Of these parishes twenty-two now have no churches at all: seventy-four contain less than 100 souls each, and 268 have no parsonages, whereas in old times every parish had a church and house for the parson. Is it a sign of augmented population, ease and plènty that out of 731 old parishes in Norfolk 268 have suffered the parsonages to fall into ruins and their sites to go waste?"

The last census prior to the present war brings our comparison up to date as nearly as can be stated. There were then 731 old parishes in Norfolk, ninety-seven of which made a return showing that each of them only possessed less than a population of 100 individuals. This year of 1918 the old parish of Upper Eldon in Hampshire has only three dwellings in it, one a farmhouse and two cottages, with a population of nine souls. The church belongs to the twelfth and thirteenth centuries with a rectorial area of 276 acres. Is it to be wondered at that agriculture has suffered?

The countryside was well populated with a prosperous and happy people when the old houses of which we have been talking were built, and the ancient sanctuaries of England came to be set up, but after making every allowance the fact remains that in the aggregate, since the Crown robbed the Church of its ancient holdings and appropriated Ecclesiastical supervision of the countryside, agriculture has suffered badly. Autocratic kings and ambitious politicians felt the inconvenience of clerical dominance. Though the monks were landlords, they did not become rack-renting landlords, and could not become absentee landlords. Truth to tell, the English clergy during the Middle Ages were honourably distinguished for their morality as compared with churchmen on the Continent. Hunting saved the situation in this country, where the "Hunting Abbot" was succeeded by the "Hunting Parson." The love of sport as a factor was a godsend, and had a restraining influence upon both parsons and people before the drab days of the smug Puritans, who sought to rob life of innocent picturesqueness, the killjoys in this workaday world where there are sufficient real sins without inventing imaginary ones. Before the days of the Reformation the Church was a world to live in, and not a building to go to, it was the centre of every parish, and churches were not only used for worship but served for a variety of semi-secular purposes. Religion entered into the common life of the people. Church plays were picturesque, and Morris dancers let themselves "go" for the amusement of the laity in a free and easy way. Of course there were comic parts, and in this pious drama a spade was called a spade. Some of the characters were far from refined in the tea-room sense, but the intentions of the players were healthy. When visualising the picturesque and considering the environment of such a community, always at war with necessity and emerging from the twilight of primitive conditions, it is necessary to take into account a few pertinent facts, and among such occurs the intimate familiarity first-hand with death, an unquestioned belief in the realities of the future state, the immortality of the soul, the personality of the devil, as well as of the Deity, and the imminence of the Day of Judgment. They sculptured their demons as they handled their pets, and the last ordeal, the weighing of souls, constantly furnished a popular subject for mural decoration. Satan possessed at least an individual charm in a sense that in these plays performed in church our forefathers were enabled to turn the flank of terror by forcing a merry and even jovial acquaintance with the unseen world. The uncanny wakes, with their incantations round

the bedizzened corpse, derived from pagan usages at the outset, were barbaric enough, but such orgies, nevertheless, had become in a crude way expressive of something more vivid by being based upon a reliance of hope which anyhow certainly is absent in the cold unpicturesque dignity of despair of our modern funerals.

Whatever the picturesque extravagances of the Mediæval church plays, they were incomparable with the bald directness and dirty drolleries which distinguished the seventeenth-century drama as best represented by sparkling Congreve and his emulator, William Wycherley. Their patron in chief was the beautiful Barbara, Countess of Castlemaine, who ended her days in obscurity.

The knockabouts and mummeries of the Middle Ages found a counterpart in the joy of the grotesques of the old masons and wood-carvings as in the misereries of chancel stalls, which excel in fun without suggestions of nastiness or loss of humour. The picturesque open-air processions which marked Rogation days, and the quaint services held for the blessing of seed-time and harvest as the seasons came round were interspersed by the festivals of "red-letter days." Think of the vast wealth of beautiful workmanship and artistic productions done everywhere at that period and compare them with the lifeless efforts of the "all buts" of our own time. "The yokel," as you call him, found what pleasures he had at home; he rarely travelled, and held the right of living on the soil inherited from the serfs. Open country was unknown, and England was so densely wooded that it was said a squirrel could traverse the kingdom without touching the ground. Witches and outlaws haunted the forests to the injury of loyal liegemen, but, notwithstanding, Shakespeare assures us the magic of the British woodland was "more free from peril than the envious court." Shakespeare, ever inspired with serene stagecraft, transferred his loved forest scenes from play to play. "Back to the land," he urges again and again because he knew it well, and his cure for human sins was a simple return to nature.

The pillage of our churches and religious houses by the government was resisted by our forefathers. This fact is abundantly clear, and the following quotation from the city archives of Exeter is a case in point from a contemporary record by John Hoker, chamberlain of the city from 1555 to 1601. He gives a picturesque account of the despoliation of the Priory Church of St. Nicholas in Exeter, when the "Comyssioners" appointed by the Parliament of 1535 came to this "Citie yn the somer tyme to exequute theire Commissyon and begynnynge first with the priorie of St. Nycholas after that they viewed the same they went thense to dynner and commanded one yn the time of theire absence to pull downe the Rood lofte yn the Churche. In the meane while and before they dyd returne certeyn women and Wyffes yn the Citie came yn at last to the said Churche, some with spykes, some with shovells, and some with suche tooles as they could geyte, and the churche door being fast they broke it open. And fynding there the man pullynge down the Roode lofte, they all sought all the meenes they could to take hym and hurled stones unto hym. In so mich that for his satifitie he was dryven to take the Toure for his refuge and yet they pursued hym so egerlye that he was enforced to leape out at a wyndo and so to save hymselff and very hardely he escaped the breakinge of his necke but yet brake one of his rybbes."

Norfolk has some of the largest and most beautiful churches in England, and the native artificers would be difficult to match nowadays with all our educational schemes and architects or schools. The people who did such work were not priest-ridden, neither was the country sparsely inhabited. The vast mortality during the Black Death and subsequent plagues proves the fallacy of such assertions.

The essentials of the picturesque are beyond the scope of superficial affectation, and it is due to that fact that so very few modern buildings are marked by that restful quality, because our contemporary work is too self-conscious and pretentious, lacking simplicity.

A dwelling is not an abstraction only to be reckoned as an adroit performance, a mere pile of timber and tiles, or bricks and mortar, peopled by a given number of souls. A house should possess a soul of its own, distinct and characteristic, a personal conglomeration of life with its own peculiar essences, flavour, and feeling as well as romance. The French emphasise this essential of a habitation by always speaking of the family residence as "the house."

Our modern disorderly England has changed materially during the last fifty years, and, strictly speaking, it is not an old country, but a new one. Sanitary science and surgery, the haphazard developments of industrial enterprise, the transport system, overcrowding of

industrial centres, repressive measures against land-ownership among many other political circumstances out of place to mention here, have combined to inaugurate a new age of experiment rather than consistent progress. England of the thirties was an old country, bearing a far closer resemblance to England of Tudor Elizabeth than that of George V. When Mr. Direck arrived in Essex from America he said "he thought he had come to the England of Washington Irving, but found it not even the England of Mrs. Humphrey Ward." Rural life, in the meantime, has been avoided for its dulness and monotony, but what we want in this country is more air, a keener understanding of picturesqueness and joy of life which is a question of balance, a fuller and freer social life. Better country housing is the problem of the hour. We have greatly overdone herd life, so that at the outbreak of the war three-fourths of the population was compacted in urban centres, leaving less than a fourth for rural occupation. The defacing disease of vulgarity is the natural product of herding in towns, and is by no means a matter of class. We have already realised the urgent need of the home production of food. The privations consequent upon the war have, therefore, accomplished much towards making the land question in the United Kingdom a practical and remunerative concern. We must sweeten our workshops, extend small-ownership, and promote the amenities for well-being; cleanse our dirty disorderly railway stations, consume our smoke, and improve the homes of those who are to be employed on farming and the production of foodstuffs, and this problem of tackling rural housing must be based on artistic and economic lines. Standardised cottages schemed on a schedule would inevitably prove a gigantic and enormously expensive catastrophe. All "arty" fuss and preconceived official ideas must be abandoned in favour of sound, well-shaped, straightforward, healthy tenements designed with strict regard to local materials and differing districts. Environment must not be ignored by the adoption of stereotyped plans. Every cottage ought to be made worthy of the name of home and be in harmony with the garden and the hedgerow. We cannot afford to spoil further the beautiful landscapes of England, and the rural charms of the countryside must be conserved by these elementary essentials. They constitute actually fundamental assets worth fighting for, but when the battle is over we shall need all our energies to prevent ill-considered schemes from being undertaken to the detriment of all classes and real prosperity. The achievements of the past and the experience of the ages which made England great must be brought to bear upon the task which lies before us in the near future. "Idealism has ever been the great driving force of all history." Let us not perpetuate makeshifts, for they are futile.

The paper was illustrated by a number of interesting lantern-slides.

DISCUSSION.

The Chairman (Mr. John Slater, F.R.I.B.A.), in opening the discussion, said it was well to note that beauty and picturesqueness were by no means the same thing. For instance, in a Greek temple there were the most perfect accuracy of line and the most delightful proportions combining to produce a beautiful building, which, however, could hardly be called picturesque; whilst picturesqueness was obtained to the full extent in some of the Flemish town-halls, with their irregular plans, steeply sloping roofs and bulging gables. As the author had said, buildings to be picturesque must be real and not sham: he did not know anything more depressing than the sham classic structures which had been erected as ruins round Virginia Water. The author had said that the Gothic revival failed, and perhaps it did in one sense, when it endeavoured to carry the principles of Gothic architecture into practical use in buildings which were not suitable for them; but it had left some magnificent monuments, and, personally, he never ceased admiring the beautiful proportions and the wealth of detail of the Victoria Tower of the Houses of Parliament. He agreed with the author that in all localities the local materials ought to be used as far as possible; if that was done an architecture was obtained which differentiated one part of the country from another. An example of that was to be found in the Horsham flags, which gave a delightful effect to the roofs of Sussex buildings, with the play of colour caused by the lichens and the stonecrop growing on them. It must not be forgotten that plan was an essential feature both of beauty and of picturesqueness, and he could never without wrath find himself bound down by the terms of the London Building Act, which enforced an absolute line of frontage for all buildings facing London streets. He did not agree with the author that one must look to the Dark Ages for the greatest picturesqueness; many Elizabethan and Jacobean buildings were both beautiful and picturesque, and some Georgian buildings possessed the most delightful balconies that could be found anywhere.

Mr. H. H. Statham, F.R.I.B.A., in proposing a vote of thanks to the author for his admirable paper, said he agreed with practically every word of it. With regard to the definition of picturesqueness, he thought it depended a great deal upon

what was called "character," which was a quality very difficult to define. As the Chairman had said, a Greek temple was not picturesque, and it certainly had not character. He thought character was shown by what was done in order to meet some particular demand or taste of the person erecting the building. He agreed that the Gothic revival eventually failed; but, speaking as one who had been an architectural pupil at the time of the revival, he could say that it had one great advantage—it gave students a passion for architecture. The buildings that were erected shortly before the revival could not interest them very much, but when they began to study mediæval architecture they felt they had found a subject which it was worth while pursuing with passion and devotion, although the revival had not succeeded ultimately. The slide the author had shown of a charcoal-burner's hut reminded him of Browning's "Sordello," where he described the supposed beginnings of architecture, and spoke of the Stone man as "dreaming, and shaping his dream into a door-post." He was very much in agreement with what the author had said about the sham picturesque architecture of modern days. He had noticed that particularly in going over the recent garden cities. There one saw houses with very lofty roofs, which were not necessary now, and were only built in former times because the architects then had not sufficient knowledge of timber construction to make the roofs flatter. One also saw houses built with very small windows because old cottages had very small windows, in spite of the fact that there was no reason now to make the windows small, and that they were very unhygienic. Such cottages ought to be swept away, and garden cities should be formed of the best small houses that could be built at the present time, with the materials that it was the natural custom to use now. He had even thought—though people in search of the picturesque might be horrified at the idea—that houses ought to be built now with flat concrete-steel roofs. That might eventually be thought the best plan, and if it were adopted a method of treating that kind of building would very likely be found that would give it a picturesqueness and character of its own. At all events, in garden cities buildings should be avoided which aimed at being imitations of old houses which were unsuitable to our modern habits of life, and which were only imitated now because people thought them picturesque. They were not designed to be picturesque by the men who built them; they were merely the best that could be done at the time, and to copy them now was only to provide an elaborate sham.

Mr. W. Woodward, F.R.I.B.A., in seconding the vote of thanks, said the paper was a deeply interesting one, and afforded much food for thought. The last few sentences were of special importance at the present time. It was well known that the Government proposed to build something like half a million houses for the working-classes, and it was a matter of moment to everyone that at all events those that were built in the country should be built in a picturesque manner, without any standardisation, and with due regard to the materials of the particular localities in which they were erected. He agreed with the author that we should not be afraid of our architecture looking new, because there was no doubt whatever that picturesqueness was to a very considerable extent due to the effect of time. If he were to erect a lych-gate to-day precisely similar in design and production to a lych-gate of the fourteenth century, one would look picturesque, because of the growth upon it, the result of time, and the other would perhaps be passed by unnoticed.

The resolution of thanks was carried unanimously, and the meeting terminated.

CORRESPONDENCE.

INDUSTRIAL BANK.

An Industrial Bank supported by the Government, in this country, to my mind is now essential.

The amalgamation of large joint-stock banks does not help the small trader.

If it were possible, without issuing more paper money (which would destroy currency), to have or institute a Clearing House of the World's National Debts, this would bring money back into trades.

D. R. Broadbent.

GENERAL NOTE.

Dyes from Wattle.—Experiments conducted by Mr. James Weddell, of Natal, for the purpose of ascertaining the value of wattle extract for dyeing purposes, says *South Africa*, have so far proved successful that he claims to have obtained some thirty shades, ranging through browns, drabs, greys, and fawns. Tests made with woollens and cottons were satisfactory, the effect of washing being rather to darken the shades than otherwise. The secrecy which formerly surrounded the German dyes has been denounced by manufacturers as a myth, and it has been found that equally fast dyes can be obtained from several woods with permanent effects. Some of the khaki shades issued to the South African soldiers at the beginning of the war were most disappointing, for they would not stand a wash, being apparently produced in a hurry. Should the wattle shades prove to be lasting another industry will be added to the list already growing in South Africa.

Owing to the further restrictions on the supply of paper, it has been found impossible to include the usual list of "Meetings for the Ensuing Week."

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, MARCH 22, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

LECTURES ON "THE FREEDOM OF THE SEA."

The Council have made arrangements for a special course of three lectures on "The Freedom of the Sea," to be delivered on Thursdays, May 2nd, 9th, and 16th, at 4.30 p.m. The first lecture will be given by Mr. GERARD FIENNES, the second by SIR FRANCIS TAYLOR PIGGOTT, LL.M., and the third by Mr. JOHN LEYLAND.

CANTOR LECTURES ON "MILITARY EXPLOSIVES OF TO-DAY."

The Cantor Lectures by Mr. J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, on "Military Explosives of To-day," will be given on Monday afternoons, April 8th, 15th, and 22nd, at 4.30 p.m., instead of 8 p.m., as previously announced.

INDIAN SECTION COMMITTEE.

A meeting of the Indian Section Committee was held on Friday, the 15th inst. Present:—

Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I. (Acting Chairman of the Committee), in the chair; Sir Arundel T. Arundel, K.C.S.I., Thomas Jewell Bennett, C.I.E., Sir M. M. Bhownaggree, K.C.I.E., Sir Valentine Chirol, Colonel Sir Thomas Hungerford Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc., Sir Henry Evan M. James, K.C.I.E., C.S.I., Sir Frederic S. P. Lely, K.C.I.E., C.S.I., Colonel Arthur H. Glendowe Newcomen, C.I.E., V.D., J. A. Voelcker, M.A., Ph.D., F.I.C., Colonel Charles Edward Yate, C.S.I., C.M.G., M.P., with S. Digby, C.I.E. (Secretary of the Section).

FIFTEENTH ORDINARY MEETING.

Wednesday afternoon, March 20th; SIR HENRY TRUEMAN WOOD, Member of the Council of the Society, in the chair. A paper on "The Food Situation in Germany" was read by Mr. PERCY SHUTTLEWOOD.

The paper and discussion will be published in the *Journal* of April 26th.

PROCEEDINGS OF THE SOCIETY.

TWELFTH ORDINARY MEETING.

Wednesday, February 27th, 1918; The RIGHT HON. LORD FARINGDON in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Alley, Stephen Evans, J.P., M.I.Mech.E., Shrewsbury.
Briggs, Francis Henry, Knighton, Leicester.
Chatfield, William Charles, New Zealand.
Davey, Hon. Arthur, J.P., Godalming.
Hart, Sidney George, London.
Leetham, Sidney, York.
McArthur, Thomas, Liverpool.
Reid-Hyde, Major James, London.
Rogers, Henry, Birmingham.
Smith, Alfred, Keighley.
Stewart, Murray, London.
Turner, Sir Montagu Cornish, Romford.
Woodthorpe, John Brinkler, F.C.A., Vancouver, British Columbia.

The following candidates were balloted for and duly elected Fellows of the Society:—

Chiura, Captain T., Osaka, Japan.
Davies, Rev. John Llanfair, Pembrokeshire.
Dilke, Sir Charles Wentworth, Bt., Brighton.
Frank, Robert, London.
Manville, Edward, M.I.E.E., London.
Moore, Thomas Cartlich, J.P., Stoke-on-Trent.
Nisbet, James Richard, London.
Rait, George L., Surbiton.
Ridge, H. Mackenzie, M.I.M.M., London.
Smith, C. Thomas, Nottingham.
Snell, Sir John Francis Cleverton, M.Inst.C.E., London.
Warnes, Arthur Robert, Hull.

The paper read was—

THE ORGANISATION OF COMMERCIAL INTELLIGENCE.

By SIR WILLIAM H. CLARK, K.C.S.I., C.M.G.,

Comptroller-General of the Department of Overseas Trade (Development and Intelligence).

A notable effect of the crucial strain which has been placed on our economic resources by this huge and protracted war, has been an impulse towards a general stocktaking of our commercial and industrial methods, and more especially perhaps towards a critical examination

of the relations of the State and trade. The fabric of British industry has borne magnificently the heavy burden which has fallen upon it, and has presented a unique example of how the productive force of a nation can be diverted from its normal channels to the task of producing weapons of destruction and every class of military equipment; but the very thoroughness with which this has been achieved means that there are difficult times ahead of us before, when the war is over, industry can be fully restored to its normal functions. And anyone who looks forward at all cannot feel any serious doubt but that after the war there will be probably the fiercest competition for foreign trade which has been seen since our merchant adventurers first sailed the seas. The war has necessarily interfered to a very serious extent with overseas trade. Restrictions have had to be imposed upon export in order to secure the conservation of supplies and the prevention of goods reaching the enemy; in order to economise shipping, raw materials, and labour, and to divert them into the uses for which they are most required. As the war goes on, this process must become increasingly severe and trade grow more difficult; yet it will be vitally necessary for us to reconstitute and to develop our export trade as quickly as possible after the war, in order to strengthen our exchanges; and indeed the only certain way of replacing the wealth which has been destroyed must be for us, and for other nations alike, to increase and develop trade. Everyone, therefore, must recognise the vital importance of the whole commercial and industrial field being thoroughly explored, and of all steps being taken to secure that the wisest policy is pursued in relation to our trade, and the best machinery placed at its disposal. It is in regard to one element only in the problem that I propose to speak to-day—the question, namely, of what the State can do to assist trade, apart from the larger and more debateable issues of financial and commercial policy. I propose to discuss briefly what the organisation for this purpose should be, and to explain what has been and is being done by the Government in this country to strengthen and expand our machinery, so that it may be more fully capable of meeting our future needs.

Functions of a Commercial Intelligence Organisation.

What then are the proper functions of a Department of Overseas Trade—a department constituted simply and solely for the assistance of manufacturers and traders in promoting and extending their business? Such a department should clearly comprise a thorough and efficient machinery for the collection and dissemination of commercial information. It should be able to supply information and advice on all matters relating to overseas markets; on the conditions and prospects in them for British trade; and on the openings which they afford for business. It should possess comprehensive particulars of buyers and importers in overseas countries, classified according to the articles in which they deal, who may be likely to require British goods. It should be able to answer questions on foreign and colonial tariffs, and on all regulations affecting trade, such as customs regulations, and requirements relating to commercial travellers, investment of capital, and so on; and should have readily available commercial statistics bearing on all aspects of trade. It should be able to furnish reports on foreign competition in the various markets of the world, such reports being illustrated, wherever possible, with samples of the goods competing with British products. The question of competition should also be studied, not merely in the actual markets, but also from the point of view of the industrial and commercial methods and organisation of our principal commercial rivals in their own countries. It is clearly very important that our manufacturers and merchants should have at their disposal such information as can properly be obtained on what is being done in other countries, where business methods, as here, are constantly being tested and reviewed. It does not follow that our rivals' methods are necessarily better than our own; but it may safely be said that they will always repay study, and perhaps have not been sufficiently studied in the past. Then there is information relating to sources of supplies of raw materials for industry, an important branch of commercial intelligence which has been dealt with in this country mainly by the semi-official agency of the Imperial Institute, on whose work a paper was recently read by its Director before the Royal Society of Arts. An intelligence department must be prepared also to supply information bearing on industry at home as well as on markets overseas. It must know, if only for the purpose of distributing the information it collects, as much as it can about British manufacturers and the articles which they produce, and British merchants and the articles in which they are interested; and it must have an efficient machinery for the distribution of intelligence which, as I shall show later on, is not quite so simple a matter as it may sound.

But a Department of Overseas Trade must be more than merely an intelligence bureau; it must be able to take action, within certain necessary limits, in matters relating to the promotion of trade. It must be able to follow up the information it receives, and not only to bring it to the notice of manufacturers and traders, but to help them to take advantage of it. It may have other activities as well, such as the work undertaken by the Board of Trade in facilitating the participation of British manufacturers in international exhibitions, and in organising industrial fairs. In fact, most matters bearing on the promotion of trade will come within its orbit.

Type of Organisation Required.

In order to fulfil these functions it is necessary to have an organisation at home and corresponding services abroad, whose duty it is to feed the home organisation with material and to carry out its instructions. In deciding upon the best form of departmental organisation at home, certain difficulties occur at the outset which have their root in fundamental principles of administration. Experience has demonstrated, alike in public affairs or in the management of some great business, the danger of over-centralisation and the necessity for a reasonable division of the administrative machinery into departments; but difficulty arises when the matter to be dealt with falls partly within the proper ambit of two or more departments. In the case we are now considering, it is clear that the organisation at home must be in the closest possible touch with the trade and industry of the country concerned, and this points to its being part of whatever the Government Department may be which deals with commerce; but its activities are also very largely connected with foreign countries, and it depends largely on services in those countries, which suggests, on the other hand, that it might properly form part of the Department dealing with Foreign Affairs. The problem is one which is not peculiar to this country, though we have an additional complication in the extent of the British Empire, which has also to be covered, and has to be dealt with differently from foreign states. Various solutions have been adopted in different countries. Germany, curiously enough, considering the energetic interest which the German Government have always taken in trade, did not until a few months ago possess a ministry specially responsible for commercial affairs. Such matters were entrusted to a department of the Ministry of the Interior, but commercial intelligence appears to have been dealt with mainly by the Foreign Office, which controls the diplomatic and consular services. An Imperial Ministry of Economics has now been constituted, but it is doubtful whether any rearrangement of functions has been made in relation to foreign trade. France and the United States of America, on the other hand, have for some time past had special intelligence offices, which have been part of their respective Ministries of Commerce—the Bureau National de Commerce Extérieur in Paris, and the Bureau of Foreign and Domestic Commerce in Washington. In both cases also, while the diplomatic missions and consular services are under the control of their respective Foreign Offices, there is a special service of Commercial Attachés for commercial intelligence work in foreign countries, who, though attached to the diplomatic missions, are under the control of the Ministries of Commerce. In the United Kingdom the Board of Trade, nearly twenty years ago, instituted a Commercial Intelligence Branch of their Commercial Department, whose function was to be the collection and dissemination of commercial intelligence. The Branch was started on a very small scale in Whitehall, but shortly afterwards was transferred to the City, where it developed in due course into a large department. Overseas, in connection with Imperial trade, the Board, a few years after the creation of the Commercial Intelligence Branch, appointed officers of its own, known as Trade Commissioners, in the Dominions, who are assisted by Imperial Trade Correspondents stationed at various centres; but in foreign countries the Branch was dependent for the regular supply of commercial information on the Diplomatic Missions, the Commercial Attachés attached to those missions, and on the Consular Service. The Commercial Attaché and Consular Services, as well as the Diplomatic Missions, were under the control of the Foreign Office, though the Commercial Intelligence Branch was authorised to correspond direct with Consular Officers on commercial matters; and while much good work was done by both services, the arrangement had the obvious disadvantage that the department which was to utilise the information collected was not in a sufficiently close relationship with the officers who collected it. The system as a whole, in fact, had become unnecessarily complex; and the question of simplifying and improving it has been taken under examination not only by the departments concerned, but also by important commercial organisations, the Association

of Chambers of Commerce of the United Kingdom and the Federation of British Industries, who have both recently issued reports on the subject. A committee was appointed by the Foreign Office and the Board of Trade, under the chairmanship of Lord Faringdon, to inquire into the best form of organisation for promoting our foreign trade through representatives abroad, including the Consular Service; but it unfortunately failed to come to an agreement, and presented two reports which illustrate the difficulty, to which I have referred, of allocating responsibility for these functions. While both reports were in agreement that the control of the Commercial Attaché and Consular Services should be left to the Foreign Office, acting in close consultation with the Board of Trade as regards instructions and appointments, and that both services should be enlarged and improved, one report recommended that the department which in this country should have special charge of the promotion of overseas trade should be a department of the Board of Trade, and the other that it should be a department of the Foreign Office. Fortunately the Government have been able very quickly to cut the knot. The Foreign Office and Board of Trade took counsel on the matter, and decided that the only satisfactory solution would be to create a joint department, which should form a sort of bridge between them, and should be entrusted with the functions in respect of commercial intelligence and the development of overseas trade, which are so largely common to both.

Department of Overseas Trade (Development and Intelligence).

A new department has accordingly been brought into being, under the sonorous title of Department of Overseas Trade (Development and Intelligence). Parliamentary control over it is exercised through a new Parliamentary Secretary, who occupies the position both of Additional Parliamentary Secretary at the Board of Trade and of Additional Parliamentary Under-Secretary for Foreign Affairs. He is responsible to the President of the Board of Trade for all matters within the competence of that department, and responsible to the Secretary of State for Foreign Affairs for all matters concerning the Foreign Office. The official head of the department, who is styled the "Comptroller-General," is also an amphibious personality, appointed jointly by the President of the Board of Trade and the Secretary of State for Foreign Affairs. The appointment and control of the Trade Commissioners within the Empire rests as at present with the Board of Trade, and the appointment and control of the Commercial Attachés and Consular Officers with the Foreign Office; but the Board of Trade have entrusted to the new department the control of the Trade Commissioner Service, and the Foreign Office have handed over to it the control of the Commercial Attaché Service, and propose similarly to hand over the control of the Consular Service when premises can be found for the new department in close juxtaposition to its own offices. In the meantime, a further link is established by the Commercial and Consular Department of the Foreign Office being placed under the new Under-Secretary. The new department comprises the former Department of Commercial Intelligence of the Board of Trade, including the International Exhibitions Branch and the organisation of British Industries Fairs and sample exhibitions, and has taken over work and staff from the Foreign Office connected with its special functions. It has also incorporated the temporary War Trade Intelligence Department—a department which has collected an immense amount of information during the war—and certain sections of the work of the Foreign Trade Department of the Foreign Office. It is intended that there should be a constant interchange of staff between the new department and other departments of the Foreign Office and the Board of Trade, and that Commercial Attachés, Trade Commissioners and Consular Officers should serve in it for a period of training.

I am afraid that I have dealt with this aspect of the question in somewhat tedious detail, but it is really of fundamental importance. The scheme which I have just described is a comprehensive attempt to solve a problem which is not a new one, but which for some years past has been urged on the attention of H.M. Government by the commercial and industrial community. Their criticisms have been specially directed against the duality of the former system, under which, while the direction of the Commercial Attaché and Consular Services rested with the Foreign Office, the utilisation of the fruits of their commercial work lay with the Board of Trade. Under the new scheme the direction of the commercial work of the foreign services and the distribution of the intelligence collected by them will be dealt with by a single department, and as the same department will also direct the Trade Commissioner Service within the Empire,

uniformity of policy will be secured in respect of overseas trade as a whole. The new department is authorised to take action arising out of its commercial intelligence work in connection with the promotion of overseas trade, subject of course to the exceptions that the larger issues of commercial and industrial policy are, and must remain, the concern of the Board of Trade, and that all matters affecting relations with foreign Powers are, and must remain, the concern of the Foreign Office.

Organisation of the Department.

In organising the Department we have had to contend with the usual difficulties arising out of the war—shortage of staff and the difficulty of securing adequate accommodation. The general framework, however, has been laid down, and the gaps can easily be filled up later on. The department has been constituted in three main divisions—the Overseas Division, the United Kingdom Division, and the Exhibitions Division. Of these the two first are the divisions which deal with the collection and distribution of commercial intelligence. The Overseas Division, which deals primarily with all correspondence from abroad and especially with correspondence with the Commercial Attachés, Consuls, and Trade Commissioners, and which is responsible for the administrative work connected with the Commercial Attaché and Trade Commissioner Services, has been divided up into a number of geographical sections and subsections, which can be added to as the work and the staff develop. The United Kingdom Division, which handles the correspondence with firms in this country and the distribution of commercial information, has been divided up into sections and subsections according to groups of trades, together with special sections for tariffs, statistics, transport, finance, etc. The organisation, in fact, aims at specialisation, and enables us to take advantage of the special knowledge or qualifications possessed by particular officers, in relation either to particular markets or to particular industries. The Exhibitions Division deals with the organisation of the British Industries Fairs, sample exhibitions, and so on, of which I shall have something to say later on. We possess a commercial reference library, where we file quantities of British and foreign trade papers and books of reference of all kinds, a sample room for the display of samples collected from abroad, and an inquiry room where oral inquiries can be made. So much for the general outlines of the organisation at home.

Overseas Services. The Trade Commissioner Service.

If the work of a department concerned with overseas trade is to be of value, it is clearly essential that it should have an efficient network of correspondents throughout the world. I have already alluded to our overseas services, the Trade Commissioners, and the Imperial Trade Correspondents within the Empire, and the Commercial Attachés and Consular Officers in foreign countries, but it is necessary to describe their organisation and work in rather more detail. The Trade Commissioner Service is of comparatively recent origin, having been instituted by the present Prime Minister when President of the Board of Trade after the Imperial Conference of 1907. Four Trade Commissioners were then appointed—one for Canada and Newfoundland, and one each for Australia, New Zealand, and South Africa, each having the assistance of a number of Imperial Trade Correspondents stationed in various districts of the Dominion concerned. The Commissioners' functions are to keep in close touch with the Government and State authorities in the Dominions; to visit the principal commercial centres; to watch and report upon foreign competition, on financial and trade conditions, and new legislation affecting trade; to make an annual general report on the conditions and prospects of trade in their areas; and to furnish special reports and monographs on particular questions which are likely to be of interest to British trade. They are also expected to supply a regular flow of commercial information of all kinds; to maintain an active correspondence with firms in the United Kingdom who wish to extend their trade with the Dominions; and to give all possible assistance to representatives of British firms who may visit their areas. An encouraging testimony to the value of the work of the service is to be found in the steadily growing volume of their work, and in the enhanced interest taken by the commercial community in their periodical visits to this country. Their work was investigated by the Dominions Royal Commission during their tour through the Empire, and the Commission reported strongly in favour of an extension of the service. The Board of Trade had simultaneously been engaged on a scheme for this purpose, and it has now been decided to increase the number from four to fifteen or sixteen. So far as the allocation of posts in the enlarged service has been decided, it is proposed that four shall be stationed at important centres in Canada; two in Australia;

one in New Zealand; two in South Africa; two in India; one in the West Indies; one in the Straits Settlements, and one will be available in the department for special service. With the assistance of a selection committee, appointments have now been made in addition to the four officers who already hold posts in the service; and an officer is already on his way to India to open up the office in that important area. It has also been arranged, after discussion at the Imperial War Conference of last year, that the Trade Commissioner in any particular area shall also be at the disposal of any of the Dominions or of India which may not have representatives of their own in the area concerned—in other words, it will be part of his duty to promote inter-imperial trade as well as the trade of the United Kingdom.

The Commercial Attachés.

In foreign countries there has been for some years, in addition to the Consular Service, a service of Commercial Attachés attached to certain embassies and legations. The service, prior to the war, comprised eight officers, several of whom had charge of very large and unwieldy areas; a single officer, for instance, had to cover the whole of Austria-Hungary, Italy and Greece, and there was only one officer for countries so vast as Russia or China. The Commercial Attachés, therefore, had in many cases to contend with very considerable difficulties. The Foreign Office now propose to develop the service on a thoroughly comprehensive scale. A committee was appointed last year, which has drawn up a scheme to cover all foreign countries of commercial importance; to provide the Commercial Attachés at the principal posts with assistants; to equip them with sufficient office allowances for the provision of adequate staff; and generally to place the service on a strong and suitable footing. A first instalment of the scheme has been sanctioned, and will enable us to proceed at once with the work of filling the more important posts. A selection committee has been appointed to review candidates and to make recommendations to the Secretary of State, and has already entered upon its duties.

The efficiency of our commercial intelligence system, and of trade representation generally in foreign countries, will in future depend to a very large extent upon the Commercial Attaché. While it is very desirable that he should not be too much absorbed in the work of the embassy or legation to which he is attached, the head of the mission will naturally turn to him for advice on commercial questions. It will also be part of his duties to superintend the commercial work of the Consular Officers in his area; he will often have to call upon them for information, and much of their work will thus tend to be focussed through him, so that he will be able to exercise a considerable influence upon it. He will have to deal with the larger inquiries affecting the trade of the country as a whole; and to furnish an annual report and monographs on special topics. An important part of his functions will be to keep in close touch with British Chambers of Commerce in foreign countries, and with the British commercial community generally, and to assist them in every possible way; and we hope that it will become increasingly the practice of British business men who visit foreign countries to call upon the Commercial Attaché and to maintain close relations with him.

Generally speaking, both in the case of the Trade Commissioners and Commercial Attachés, the efficiency of the services must depend largely on the initiative, energy, and experience of the officers themselves. Instructions are being prepared for them, but no instructions, however comprehensive, can in themselves enable their recipients to cover satisfactorily the whole field of their activities. The rest must be left, in part, as I have said, to their own initiative and in part to the guidance which they should receive through constant communication with the Department and through the relationships between them and the business community. In developing these latter, we have found that it is very useful to bring officers home at regular intervals and to arrange tours for them—with most valuable co-operation from Chambers of Commerce—through the principal commercial and industrial centres of the United Kingdom. This has been the practice for some time past, and has been attended with very good results. The demand for interviews is so considerable that the time spent in one of these tours now amounts to over four months, and the officer has to undertake some hundreds of interviews, besides giving addresses to Chambers of Commerce, Trade Associations, and so on. At the same time, he takes the opportunity of inspecting works and factories, and familiarising himself with the products and methods of British manufacturers.

The Consular Service.

The question of strengthening the Consular Service by a revision of the present posts and pay, is also under examination by the same

committee which drew up the scheme for the Commercial Attaché Service, and I hope that the result will be to remove some of the disabilities under which the service has laboured in the past. More posts are required and a more generous provision to meet the cost of residence in certain countries. It is not possible for me, in the course of this brief survey, to enter on any detailed discussion of the constitution and working of the service, but I would ask you not to accept too hurriedly the criticism which has been somewhat freely directed against it from time to time. Much of this criticism has not been fair in itself, and it has failed to take into account the difficulties with which many Consular Officers have had to contend. A large proportion of the officers, in my experience, take a genuine interest in their commercial work, and expend much pains on it; and supply us with really practical and useful information. With more systematic direction and guidance in their work, I see no reason why very good results should not be obtained.

Special Investigations of Overseas Markets.

Closely connected with the question of the overseas services is that of the expert investigation of markets abroad. However efficient the permanent official representative may be, it will frequently be necessary to supplement the intelligence which he sends home by special inquiries. All our representatives cannot be men who have had actual business experience, and even if they do possess such experience in one or another class of business, they would not be in a position to furnish reports as experts upon all of the large variety of trades with which they may be concerned. On the other hand, experience has shown that expert investigation of markets is becoming more and more necessary. The Board of Trade have frequently in the past despatched special commissioners to investigate particular markets and to report upon the conditions and prospects in them for British trade. Such missions have been sent to South and Central America, Canada, Australia, South Africa, Japan, Persia, China, and to Russia. In these cases the commissioner has been charged with the duty of reporting on the prospects of British trade as a whole, but the growing intensity of competition between manufacturers of various classes of commodities for the trade of the large consuming markets has made it increasingly desirable that the market should be surveyed in respect of the openings for any particular industry by men with specialised knowledge of the conditions of the industry in this country. During last year three technical investigators were sent by the Board of Trade to Spain, charged with making inquiries in respect of certain limited ranges of goods, one investigator taking the electrical trade, another marine engineering, and the third the iron, steel and engineering industries. The reports have now been received, and there seems little doubt that the method pursued has been justified. It is a method, I may say, which has been adopted to a very considerable extent in the United States, where the Bureau of Foreign and Domestic Commerce, in addition to having Commercial Attachés at certain centres abroad, has in the last few years conducted a number of specific trade investigations in respect of various industries in several markets of the world. The Board of Trade last year carried the matter a little further, and took up, with the assistance of their Advisory Committee on Commercial Intelligence, the question of co-operation with the trades themselves in joint investigations of particular trades in overseas markets. Such investigations had been urgently pressed by some of H.M. Trade Commissioners and Commercial Attachés, with a view to cultivating markets for trade after the war. H.M. Commercial Attaché in the Argentine especially urged that, in order to make these investigations effective, it was desirable that an investigator should be selected by the trades concerned, but that he should go out with the support and assistance of Government. A special sub-committee of the Advisory Committee was appointed to investigate the matter, and to take evidence from trades which seemed especially suitable. They recommended that the Board of Trade should actively take up the question of facilitating the formation of export associations of manufacturers, especially with a view to despatch by such associations of expert investigators to approved overseas markets, and that Government should contribute to the cost of the inquiries. The Board of Trade accepted the report, and one such investigation has already been arranged for. The Department of Overseas Trade has been in communication with representative associations in the jewellery, silverware, and electro-plate trades, and as a result arrangements have been made for a joint investigation of the South American markets, the cost of which is being defrayed in part by the trades and in part by H.M. Government. The associations concerned have done us the compliment of selecting an officer of the Department for the inquiry who had had several years'

experience in the trade before entering Government service; and he has spent some months in studying products and methods of manufacture of the firms concerned before starting on his tour. He will carry samples in order to show what is being made in this country, and will collect samples of competitive goods in the South American market. This scheme has been the cause of a certain amount of misapprehension and criticism, on the ground that it is an undue interference with individual enterprise, and one which may result in the deflection of trade from its normal channels. There is, of course, no such intention on the part of the Government, and I see no reason to suppose that it is likely to occur. The investigator will not book orders. The whole object of the inquiry is to place in the hands of British manufacturers accurate information as to the types of goods most in demand and the conditions required by their customers, and thus to facilitate a ready adaptation of their patterns and methods to meet the varying requirements of different markets. The special merit of the scheme is the close co-operation involved between Government and the manufacturers concerned. Such co-operation, it seems to me, is far the most efficacious method of securing that the work will be directed on lines which will be most practical and useful to the trade.

Relations with the Commercial Community.

Not the least important in fact of the problems which a commercial intelligence department has to solve, is how it shall maintain the closest possible touch and secure the most effective co-operation with the commercial community which it is to serve. Such touch is essential in order that the department may know how best to direct its overseas services, and how to distribute the commercial intelligence which it collects from all parts of the world. With this object in view, an advisory committee of business men is shortly to be appointed to assist the Department of Overseas Trade in its work. In constituting this committee, the Foreign Office and the Board of Trade hope to reconcile what may appear at first sight to be almost conflicting requirements—namely, that on the one hand the committee should be as representative as possible of the many aspects of British trade, while on the other hand it should not be so large as to interfere with practical and efficient working, since we hope that it will meet frequently and take a real part in the work of the Department. But even more important, perhaps, than the best and most willing of advisers are the constantly growing relationships with the business world which arise out of the work of the Department. I am glad to say that the number of inquiries which were received by the former Department of Commercial Intelligence of the Board of Trade increased rapidly of late years, and I hope that with the larger scope of the new Department the process will continue even more vigorously. Such inquiries constitute a most informative record of the needs of particular firms; of the classes of goods which they manufacture, and of the markets in which they are interested. All such inquiries are indexed under the name of the firm, and we are gradually building up in this way a comprehensive and detailed index of British manufacturers and their products. This is now being supplemented and made more complete by circularising the trades concerned, and in due course it will be compiled in a form which will enable it to be placed at the disposal of our Commercial Attachés and Trade Commissioners overseas, so that, in dealing with local inquiries, they may have an authentic record of British manufacturers.

Methods of Distribution.

In addition, however, to supplying information in reply to inquiries which may be received from the outside, a properly-equipped commercial intelligence department must also have its machinery for the distribution of information upon its own initiative. The object as regards a certain proportion of such information is merely to secure as much publicity as possible, but much of it is necessarily confidential, so that machinery is required which, while safeguarding the confidential nature of the intelligence, will not prevent its reaching freely those to whom it will be of interest and value in the promotion of their trade. For the dissemination of the more public class of information, we have the *Board of Trade Journal*, a weekly paper which was formerly edited in the Department of Commercial Intelligence of the Board of Trade. It has now been placed on a much more comprehensive footing, and, by the introduction of special articles and other more readable matter than was thought necessary in the former somewhat austere paper, will, I have little doubt, secure a much larger circulation, and will be a really valuable vehicle for the distribution of our material.

For the distribution of confidential information we have two channels. The first of these,

which is known as "Form K," we owe to the ingenuity of the Foreign Trade Department of the Foreign Office, who have now handed it over to us. It is a system for supplying traders and manufacturers with information in regard to possible importers in certain foreign countries of goods of British manufacture. Such information lends itself to collection within the compass of a form, which is sent out to all Consular Officers in the countries concerned. The form ensures uniformity and thoroughness in the compilation of the reports and greatly facilitates dissemination. The items of the form comprise the main preliminary particulars which it is necessary for a firm in this country to know who are contemplating opening up business with an importer's house abroad—such as the articles in which the house is interested; their European references; the general nature of their business, and the terms on which they trade. The distribution has been arranged in co-operation with the Association of Chambers of Commerce and the Federation of British Industries, who have readily given their help and have undertaken the responsibility of communicating the information to interested firms. Firms apply to receive the reports through their representative Chamber of Commerce or Trade Association, and have to be approved by the Department. There are now over 10,000 traders in receipt of the intelligence distributed by these means.

The second channel of confidential distribution is known as the Special Register. It is kept in the Department for the purpose of passing on to firms confidential intelligence of a more general scope than that provided under Form K. While Form K, as I have explained, is confined to lists of firms in certain foreign countries, with the relevant information relating to them, the intelligence supplied through the Special Register includes specific openings for trade abroad in all parts of the world, reports on foreign competition, reports on various industries in countries overseas, and on general financial and commercial conditions. Reports on particular trades or markets which are obtained from time to time as the result of special commercial missions, are also circulated to firms on the Special Register. The Department charges a small annual fee for the service. In spite of the hampering effect of the war on overseas trade, it is satisfactory to find that the number of firms on the Register steadily increases, and is now between 3,000 and 4,000. I should be glad, however, to see it very much larger.

International Exhibitions and Fairs.

There is only one other matter on which I should like to touch very briefly—namely, the use of exhibitions and fairs as a means of promoting overseas trade and the functions of Government in connection with them. A great deal of attention has been given to this matter by the Board of Trade in recent years, and its close relationship with commercial intelligence has been recognised by the incorporation last year of the Board's International Exhibitions Branch in the former Department of Commercial Intelligence, and by the Department being entrusted with the organisation of the British Industries Fairs. The International Exhibitions Branch was established some few years before the war in order to facilitate the participation of British manufacturers in foreign exhibitions, to protect their interests, and generally to superintend the formation of the British section; and though the work has, of course, been in abeyance during the war, I have no doubt that it will revive afterwards. Exhibitions and fairs, though they differ markedly in scope and externals, have this in common—that they are both methods of bringing buyers and manufacturers together. When an international exhibition is held in an overseas country, the British manufacturer sends his goods there in order that they may be seen by the buyer in that country; the object of a fair in the United Kingdom is to secure the same end by bringing the buyer from abroad to see the goods set out in the fair here. Fairs, however, are organisations much more definitely for business purposes than exhibitions; they are usually open only to the trade, and producers exhibit with the object of transacting business and of placing orders during the currency of the fair with the wholesale buyers. All the costly accessories of international exhibitions can therefore be dispensed with. The essential principle of such fairs is that business is done entirely by sample; and consequently they are most suitable for goods which can be displayed conveniently in this way, so that firms can show their products within the comparatively narrow space of a stall where they can be inspected and where orders can be placed by trade buyers. The classic example of such fairs in the past has been the well-known Leipzig Fair. In this country they are directly a product of the war. They arose out of the efforts of the former Commercial Intelligence Branch of the Board of Trade, shortly after the outbreak of war, to assist British manufacturers in taking up lines of goods in which German competition had hitherto

been notably successful in this country, and to assist buyers who were in difficulties owing to their previously having been dependent for the commodities required in their business on supplies from enemy sources. In order to bring possible producers and buyers into touch, the Branch arranged a series of exchange meetings covering a number of trades; and the logical outcome of these was the first British Industries Fair, which was organised by the Board of Trade in 1915. It was the first fair of its type, so far as I know, to be promoted on at all a large scale in England, and I should like to take this opportunity of paying a tribute to the enterprise of the small band of Government officials who, without previous experience, undertook and successfully carried through its organisation. Since then the Fair has become an annual institution, the exhibitors at the first Fair having petitioned the Board to continue the work; and the Fair for 1918 will be held in a few days from now. The number of trades which can be included has had to be severely restricted in order to avoid any interference with the paramount necessity of the production of munitions, so that the Fair now only comprises four trades—fancy goods; china, glassware and earthenware; printing and stationery; and toys—but after the war there will be unquestionably a rapid development.

Government agency, of course, is not an essential to the organisation of a fair; for instance, since our fair was instituted, the Corporation of Glasgow have also promoted one, under the auspices and with the support of the Board of Trade, embracing certain trades not included in the London Fair; and in the first year after the war Birmingham proposes to follow their example in regard to the trades centred in their city. But Government management undoubtedly has its advantages, and I have no doubt that the London Fair will continue to be organised by the Department of Overseas Trade. We run our fair on a strictly business footing and without any grant from the Treasury, but we are able to get the cost to the exhibitor of his accommodation down to a tolerably low level, and thus to make it easier for the smaller firms to participate.

Fairs are unquestionably of great value in the development of trade. At Leipzig, before the war, the number of exhibitors had totalled 4,000, while the Fair was attended by many thousands of buyers from all parts of the world; and German trade in a long list of articles has been immensely benefited by these Fairs, at which the buyers sometimes placed orders covering their entire requirements for the year. Our fair comprises at present something over 400 exhibitors, but as the Leipzig Fair has been in existence since the Middle Ages and ours is but a three-year-old bantling, and those years of war, we need not despair of making good the difference. The Germans, at any rate, are becoming nervous about the future. They have made strenuous efforts to maintain the continuity of the Leipzig Fair throughout the war, and it was announced, not long ago, that it is to receive a subsidy of £50,000 per annum in order to help it to make good its former prestige. Our fairs, as I have said, are self-supporting; and I think we may take this anxiety on the part of the enemy as something of a compliment to ourselves and to our Allies, the French, who have followed our example in organising similar enterprises at Lyons and Paris.

Sample Exhibitions.

The exhibition method is also of value for illustrating foreign competition and the requirements of a particular market. We have a sample room at the Department of Overseas Trade, where we have at present a considerable collection of samples of German and Austrian goods which were competing with British goods in different parts of the world. We endeavour to keep these collections constantly up to date, and when we are able to form sufficiently comprehensive exhibits in particular lines of goods, we arrange for them to be shown in the industrial centres of the United Kingdom where they will be specially of interest. A series of exhibitions of this kind was held a little over a year ago, and the exhibits subsequently visited Canada at the request of the Canadian Government. Experience has proved that this class of work is of particular value to manufacturers, who are allowed to borrow the samples with a view to making a thorough technical examination of them at their works. We have recently sent out instructions to our officers overseas to collect samples of hardware and textiles in certain important markets, and these when received will be exhibited in the same way. The Department has also formed an extensive collection of foreign manufacturers' catalogues, mainly German and Austrian, which throw a valuable light on their competitive products. These catalogues are constantly on loan with British manufacturers.

Conclusion.

I have endeavoured, in putting before you this survey of our commercial intelligence

system, to avoid so far as possible wearisome detail and only to give you a general outline of our work and aims. Our organisation, of course, is very far from perfect; no small part, indeed, of the interest of the matter lies in there being always new methods to be investigated and new types of inquiry to be taken up. But if, as we hope, the foundations have now been laid on sound lines, the rest will follow quickly enough, provided the work is carried on with intelligence and energy, and provided always that we do not forget the important truth —that a Government department cannot help the commercial community efficiently unless it works in the closest co-operation with them, and not only, according to its own lights, on their behalf.

DISCUSSION.

THE CHAIRMAN (the Right Hon. Lord Faringdon), in opening the discussion, said that he had listened to the paper with the greatest interest. The subject was one with which he was fairly familiar, as he had been the chairman of the Departmental Committee that considered the question when there was a little friction between the Foreign Office and the Board of Trade. He was glad to think that that friction had been disposed of by the happy arrangement which the Government had made, and arising out of that came the new and important Department of Overseas Trade. It was certain that the keenness of competition after the war in connection with trade would be greater than anything that had been experienced in the past, and it was essential that the people of this country should have the most thorough knowledge it was possible to obtain of all conditions affecting trade both at home and abroad. There was no doubt room for improvement in our Consular Service, and also in the home service, in connection with the information which was available, but was frequently not taken advantage of. When the information arrived it was essential that it should be classified and put into such order that it was readily available for those who required it. He had repeatedly found that at the Foreign Office and at the Board of Trade a mass of information was obtainable upon different subjects, but it was not readily available; it had to be unearthed and put into shape before it was sufficiently intelligible for any one who was taking up a new subject to understand it. He thought the new Department of Overseas Trade would have a great deal to say with regard to the arrangement of the information that came before it, and he hoped that the traders, the manufacturers, and the merchants of this country would take full advantage of the Department. There was a disposition on the part of a certain number of people to say that they could obtain all the information that Government Departments possessed through their foreign correspondents, and the very people who were crying out against what they called the inefficient Consular Service of this country were those who, as a rule, were the very last to go to a Government Department for any information. It had been his duty to go to several countries abroad, on behalf of the Government, since the war began, and he had been struck, not by the inefficiency but by the wonderful efficiency of the Consular Offices that he had visited. There might be complaints of the British Consular Service, but those complaints were not limited to this country; precisely the same kind of complaints were made in every country. The people of the United States, Germany and France were continually complaining of their Consular Services, and, after all, that was a very good sign. If one was satisfied with anything it often meant that one was not taking very much interest in the subject and was going backwards instead of forwards. The appointment of the Commercial Attachés and the Trade Commissioners that had been referred to in the paper was bound to have a good and stimulating effect upon trade. The happy-go-lucky conditions of the past had to be abandoned, and more thorough methods must be introduced. In the future there would have to be less time for recreation and more time devoted to work; and, above all, it was absolutely essential that in the future modern languages should be cultivated to a greater extent than had hitherto been the case. It must be remembered that it was not only British trade that had to be considered—it was the trade of the Empire, and he was glad to note that the Trade Commissioners were not only going to look after the trade of Great Britain but were going to devote their attention to the trade of the Empire as a whole. Whatever the Government might do for the trader would only be in the nature of assistance; the British trader had depended in the past upon individual effort, and it was upon that individual effort that British trade would have largely to depend in the future.

SIR ALGERNON FIRTH, Bt. (President of the Association of Chambers of Commerce of the United Kingdom), said it was necessary at the present time for all those interested in trade to do their utmost to make the new Department of Overseas Trade a success, to still the voice of criticism and to render all the assistance they could to the Department. It should be the work of that Department to find out where this country was not getting its share of the trade in any individual article; it should go through the imports of certain countries where the articles were supplied to a large extent by foreigners, and this country was not getting a fair share of the business. Then it should lay the facts before those interested in the trade in this country, and, with the assistance of the new Trade Development Branch of the Board of Trade, some machinery should be devised whereby this country might obtain its share of the business. British traders did not look for a monopoly in any market. Possibly they had been too individualistic

in their business. Personally he was a firm believer in individuality, but also in co-operation; and if individual effort failed in any direction then the individuals concerned should meet together and see if by a combination of brains and effort they could arive at the desired result. In that way, with the assistance of the Department of Overseas Trade, success would be assured. He hoped also that the Department was going to help the traders of this country to obtain business which their German and other rivals had previously been able to obtain owing to Government assistance and the banking assistance they had been able to command. If the Government, the bankers, and the traders of this country would pull together in a similar way, a great deal more business would certainly be obtained. With regard to the debate that had taken place in the House of Commons on the previous evening on the subject of the Department of Overseas Trade, he strongly deprecated the cavilling that had taken place about the amount to be spent on the salaries of the staff of the Department. If brains were required they must be paid for, and the scale of salaries mentioned in the debate as the proposed payment of the heads of the Department was in his opinion totally inadequate. The men who undertook the responsibility of such a Department, and were supposed to supply initiative and not merely to perform routine work, ought to be paid on a very different scale from that mentioned in the debate.

Mr. Philip B. Kennedy (Commercial Attaché, United States Embassy) said that, having been for two years the American Commercial Attaché in Australia, he took a great interest in watching the development of the British Overseas Trade Department. There were two very significant features in its development: first, that all the activity relating to foreign trade had been brought under one Governmental head; and, secondly, that that action had been correlated with the business interests. In Washington there was still a gap between the Department of State and the Department of Commerce—the Commercial Attachés and the Consuls not being directly connected. There had been a considerable amount of personal co-operation between the two Departments, but he thought there was a very sound reason why it was desirable to have one common head if that was possible. The Consuls in the United States sent in their reports to the Department of State, those reports being published and distributed through the Bureau of Foreign and Domestic Commerce, and sometimes there was delay in getting them through. One could not always be in touch with men who were reporting to another Department, and there was sometimes duplication of effort. Before he entered the Commercial Attaché Service of the United States he had been for two or three years a member of the Foreign Trade Committee of the Merchants' Association of New York, and he had felt then that the members of that Committee did not always give the weight they should give to the services rendered to them by the Consular Service, so that when he entered the Commercial Attaché Service he felt doubtful whether he would be able to help them in any way. That feeling, however, had entirely disappeared, and he had found that business men were quite ready to accept any assistance that could be given to them. The United States Commercial Attachés were supposed both to follow general tendencies and also to be of specific and concrete assistance. During the war they had not had much time to devote to concrete problems, but after the war their object would be to give assistance to individual firms, and if that was to be done the Government officials must adopt the same attitude towards trade as the private business man did.

Mr. Ernest Benn said the connection between Government Departments and the commercial community of the country had never been very close, and personally he very heartily welcomed the evident desire of the new Department of Overseas Trade to take into its confidence the traders and commercial men whom it had to serve. He thought the author and his staff were to be congratulated on having done so much in such a short time to build up the new Department, but he hoped there would be no feeling that the work was finished. The author had mentioned the subject of special inquiries on behalf of special industries in special markets, which was a development of the utmost importance; and he did not think the Department should be satisfied with their work until they had arranged for an inquiry on behalf of each industry in each market, always bearing in mind that those inquiries must be made by men thoroughly conversant with the technique of the industry with which they were dealing. Sir Arthur Steel-Maitland had recently mentioned that the Overseas Trade Department was considering the setting up of Trade Committees to advise the Department on the requirements of each trade, and he hoped that those Committees would soon be formed. He thought the Department would have to watch very carefully the reconstruction process that was going on in industry at the present time, and should endeavour to make its work conform with the rearrangements that would undoubtedly be made in the near future in British trade. Traders were now beginning to realise the need of co-operating, and he thought that as a result of the Whitley Report some movement would come in which traders would realise that there were common interests between competitors and between capital and labour, the promotion of which was the best way to serve the individual interests of everyone. It was with those common interests in a trade that the new Department should especially concern itself. It would be a great advantage if the various activities of the Government could be in some way co-ordinated, so that a trade would not be confused, as it was at present, by having to deal

with a dozen different Government Departments. For instance, the National Pottery Council was looking to the Government for assistance in many directions, and it had to go to the Department of Overseas Trade for information with regard to overseas trade, to the Department of Scientific Research for help in research, to the Home Office for legislation with regard to Factory Acts, and to the Board of Education for technical education. He hoped that out of the new Department there would arise in the future some attempt to co-ordinate the relations between the Government and trade, so that on the one hand there would be perhaps a Minister of Commerce and on the other a Trade Authority in each trade. The author had not dealt with the subject of labour, but he thought the new Department had a great responsibility in that matter. Labour was now asking for a share in the control of industry. In his opinion it could never have any real share in the control of individual businesses, but it could co-operate with employers in negotiations with a Department such as the Overseas Trade Department, which might be a means of satisfying the very proper aspiration of labour to share in the higher direction of industry. If some way could be found whereby matters such as the special inquiries referred to could be negotiated, not only with capital but also with labour, it might help in the problem of industrial unrest.

Mr. G. Booth Heming said it was very gratifying to commercial men to know that they had now a Department which was going to give the whole of its energies to overseas trade. In the past manufacturers had always acted upon the conservative lines that what suited them or the people at home must of necessity suit the foreigner; but the great thing it was necessary for them to do was first to ascertain a want and then supply it. Another hindrance to British trade was the inefficiency of the Consular Service. About seven-tenths of the Consuls were foreigners, who could not be expected to take very much interest in British commerce, and if that commerce was to be increased there must be British representatives established abroad, who would obtain the necessary information and give it to traders at home, so that they could supply the goods that were required. It was always held that trade followed the flag, and that was quite true many years ago, before this country encountered competitors; but the practice now was for trade to follow the bank. The joint-stock banks of this country did nothing to help the struggling manufacturer. In Germany the Consulate and the Embassy were in touch with one another, and after they had settled themselves in a particular town the Deutsche Bank, or some other bank, also established a branch in that place. Then the bank would go to a particular firm and ask if it could assist them in any way, and eventually it would obtain a good deal of control over the business. The information was immediately sent home to Germany, with the result that a firm would be opened under a German name, and would eventually take over the business, supported by the Embassy, the Consulate and the bank, and also the home Government. The British Government, on the other hand, had done nothing for commercial men, and it was a very lengthy business to obtain any information from the Foreign Office with regard to trade.

Mr. James Munford wished to ask the author whether candidates for employment in the Overseas Trade Department would be required to have a university degree, and also whether women would be eligible for appointments in the Department at home. He knew of a case where a well-educated and experienced practical farmer had been refused a position at the Board of Agriculture because he did not possess a university degree.

Sir William H. Clark, K.C.S.I., C.M.G., in replying to the discussion, said that the Department was fully conscious of the difficulty of the work it had to do. The extent of the programme before it had been foreshadowed in some of the speeches that had been made that afternoon. Mr. Benn had referred to possible activities which would involve a very large amount of work. He had said, for instance, that the Department ought to be able sooner or later to make expert inquiries into practically every industry and every market. That was a counsel of perfection, and would be very difficult to accomplish. The question of expense had also to be considered, and he felt that such inquiries were a matter in which the trade ought to bear part of the expense. The Treasury was prepared to be generous, and he was grateful to Sir Algernon Firth for emphasising the necessity for liberal expenditure in connection with the Department, but he thought the State could hardly be expected to undertake the whole cost of the inquiries in question. He agreed with Mr. Benn as to the desirability of having one Government Department which could co-ordinate the relations of the commercial community with the Government. During the war there had been a very large increase in Government Departments controlling and dealing with trade, and it had been very difficult for traders to know to whom they ought to apply in matters affecting their trade; but his Department had tried to help in that respect, and had constantly borne in mind the importance of there being a Department to which a trader could always go for advice and information upon any matter, including, as Mr. Benn suggested, Governmental questions. Mr. Benn had also referred to the question of consulting labour as well as manufacturing and commercial interests. This was a matter that the Department was considering. It was clearly one of very considerable difficulty, and he could not say anything definite about it as yet. Mr. Booth Heming had spoken very severely about the Consular Service, but did not go into detail with regard to his charges against that Service. It was hoped that it might be improved by starting from the bottom and giving a better business training to new recruits, but it was not fair to say that it was

a generally inefficient Service. As the Chairman had pointed out, the same complaints were met with in every other country; they were even to be found in German papers, although the German Service had always been held up before this country as a model. The British Service had a far larger proportion of paid to unpaid Consuls than any other country in the world, but the unpaid Consuls could not be dispensed with altogether; nor was it necessary, as in many small places their duties were entirely uncommercial. He agreed that where it was possible to obtain an Englishman to act as Consul it was desirable to do so, but it could not always be done. In reply to Mr. Munford, a university degree was not essential in the case of candidates for employment in the Department, and a good many women were already employed there.

On the motion of the CHAIRMAN, a vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

OBITUARY.

SIR SWIRE SMITH, LL.D., M.P.—Sir Swire Smith died in London on March 16th, after a slight operation, at the age of seventy-six. He was born at Keighley, and educated in his native town and at Wesley College, Sheffield. Throughout his life he devoted himself to the cause of technical education. When twenty-four years old he was appointed secretary to the building committee of Keighley Institute, and took a prominent part in the work of reorganisation which led to the institute's remarkable success. So great was this that Professor Huxley once declared that Keighley had gone far to solve the problem of technical education; and the late Duke of Devonshire, when speaking of the National Association for the Promotion of Technical and Secondary Education, said that, in brief, its object was to induce the rest of the country to follow the example of Keighley.

Sir Swire Smith travelled a great deal on the Continent and in America to study methods of technical education. In 1881 he was appointed representative of the woollen industries on the Royal Commission on Technical Education, and he subsequently became a member of the committee of the National Association for Technical Education already referred to. He also took much interest in the work of the Exhibitions Branch of the Board of Trade.

In 1888 he read before the Royal Society of Arts a paper on "The Technical Education Bill," for which he received a silver medal, and in 1897 another on evening schools. In 1892 he was elected a member of the Society. His last appearance here was made as recently as February 13th, when he took part in the discussion on Lord Leverhulme's paper "'Zero' of Capital and Labour."

He received the honour of knighthood in 1898, and since 1915 he represented the Keighley Division of Yorkshire in the House of Commons.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

APRIL 10.—W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry." PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., will preside.

APRIL 17.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

APRIL 24.—MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons." The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

MAY 1.—GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

MAY 8.—JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India." The RIGHT HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m.:—

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912-17, "British Guiana."

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.:—

J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." Three Lectures.

April 8, 15, 22.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, MARCH 29, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Tuesday, March 5th, 1918; SIR OWEN PHILIPPS, K.C.M.G., M.P., in the chair.

THE CHAIRMAN, in introducing the author of the paper, said that Portugal was Great Britain's very oldest ally. The friendship of the two countries was deeply rooted in their history, and was intensified by the fact that just two years ago, *i.e.* on March 9th, 1916, Portugal joined with the other Allies in the war against Germany. The Portuguese soldiers had played a gallant part not only in France but also in the East African campaign, which was now on the verge of a successful termination. He could not refrain from recalling the great deeds of Portugal in days gone by, when, in the fifteenth century, her famous sailors Bartolomew Dias and Vasco da Gama were sent by their enlightened Prince, Henry the Navigator, into unknown and uncharted seas and founded a vast colonial empire in South America, Africa and the East. As chairman of the Royal Mail Steam Packet Company and of the Union-Castle Line, he might say that the former company had had a long and intimate association with Portugal and her colonial empire, its contracts for the conveyance of mails between Lisbon and Brazil dating back to the year 1850. During the present war the company had carried large numbers of Portuguese woodcutters, who had been employed in felling trees in the United Kingdom for war purposes, thus setting free for the conveyance of food a great deal of shipping which would otherwise have to be employed in the conveyance of timber to this country. The Union-Castle Line had also had a long and close connection with the Portuguese colonial empire on the East Coast of Africa as well as Madeira. He might mention that the present paper was the last of a series of four that had been read before the Society dealing with the African possessions of the Allies.

The paper read was—

PORTUGAL AS A COLONIAL POWER.

By GEORGE YOUNG, M.V.O.,
Ex-Secretary of Legation, Lisbon.

I have been asked how it is that, in addressing the Royal Society of Arts on a country so full of artistic interest as Portugal, I have chosen "Colonial Power" as a subject. But I need scarcely remind any one here that this is the Royal Society of Arts, Manufactures and Commerce, and this paper is the fourth of a series organised by the Colonial Section.

It would, no doubt, have been easier to interest you in other aspects of this most interesting people, but one is sure, to-day, of a sympathetic hearing from a British audience on any subject connected with our most ancient ally.

There is still, however, the difficulty that Portugal, though at our very doors, is as little known to most of us as the Pole. Indeed, I remember Sir Clements Markham saying, when I last met him at Lisbon, where he used to winter, that he had begun by exploring the Pole and had ended by discovering Portugal. Yet we have no excuse for this ignorance, for Portugal has been a pleasure resort since the Romans, having a perfect climate, picturesque scenery, and pleasant people. Moreover, it has been our ally for over five hundred years, the only two interruptions being when it lost its independence to Spain and to France. Here is a description of our relationship with Portugal from the "British Policy of 1347"—a sort of primitive commercial report:—

"Portugallers with us have troth in hand,
Whose marchandie cometh much into England.
They are our friends with their commodities,
And we english passen into their countries."

And if before the war we did no longer "passen into their countries," it was purely our own fault, though we must make an honourable

exception of our chairman, Sir Owen Philipps, whose Royal Mail steamers make the journey to Portugal a pleasure in itself.

If we have some idea of what Portugal is as a country and as a people, we shall find it easy to understand the past, present and future of Portugal as a colonial power, because an empire is only a sort of extra-territorial expression of the characteristics of the imperial people. We are proud of the British Empire, because we believe it to be an expression of much of what is best in our national character; and the Portuguese Empire reflects much of what is most characteristic in their race. Therefore when we realise what a large part in European progress this minor but very marked people has played, we shall also recognise that the colonial power of Portugal may, in this present crisis of civilisation, become a far more important factor than we might have supposed.

Let me, then, try to answer, in three-quarters of an hour, the three following questions:—How was the Portuguese colonial power constituted; in what does it consist; and what contribution can it make to the world which we hope to reconstruct from this waste of war?

The question how Portugal comes to be a Colonial Power has two answers. One would only require a reference to the map; the other, a review of European history. Neither being possible here, it must suffice to say that when Islamic intolerance finally blocked the direct routes to the East by Asia Minor or the Mediterranean, trade sought other indirect routes southward, along Africa, or westward across the Atlantic. For this leap in the dark geographical position made Portugal the best jumping-off place, and historical conditions made Portugal first ready to jump.

Portugal, then, by one of the curious contrarieties of history, owed its world empire to its worst enemy; for the whole history of Portugal is one long crusade against Islam. Portugal's first crusade was when the Christian refugees came down out of the Galician mountains to drive the Moor from Portus Calis, now Oporto. It was another crusade that, with English help, recovered Lisbon. Again, another in which Portuguese independence perished with the flower of Portuguese chivalry in Morocco. As late as 1717 Portugal undertook a crusade by itself, and it was not until 1843 that it signed its commercial capitulations with the Turk. Therefore the early empire-builders of Portugal were crusaders in the first place and only conquistadors or colonisers in the second. In every age we find the Portuguese pride of empire doing penitence whenever Portugal felt that it had offended against the crusading spirit.

The imperial poet of Portugal, Camoens, in his long panegyric of empire, the "Lusiad," finds place for such a protest against imperialism as the following:—

O Pride of Empire! O vain covetise
Of that vain glory that we men call Fame:
O false ideal, that finds its verities
In that vulgarity we "Honour" name.
What punishment and what just penalties
Thou dost inflict on those thou dost inflame:
What deaths and what disasters, what heart-breakings,
What hardships in thy cruel undertakings.

Now to what new disaster dost consign
This my dear native country—this my nation?
What dangers and what deaths dost thou design
Under some high and mighty appellation?
What profits from dominion or from mine
Dost thou propose for our remuneration?
What promises of Fame? What place in story?
What triumphs—what Te Deums—and what glory?

And if we come down to our own day, we find the prophet of the Republican Revolution, the poet Guerro Junqueiro, imperialist as he was, lamenting the loss of Portugal's ideals in this jeremiad:—

"I spanned the World about, new worlds among,
But not the more to worship and be wise.
A cruel greed hurried my feet along,
The pride of conquest made my sword-arm strong,
And lit the light of madness in my eyes.
I shall not wash the blood I then did spill
With tears of twice ten thousand centuries.
O Cross of Golgotha, new made in steel,
Sword of my paladins and cross of death:
Cross on which Christ bowed down for human weal—
Merciless, mighty, cutting through life a swath
To build up empires, bring the East in sway.
God breathed on them and lo! the empires fade;
But thee he planted, O thou blood-red blade,
In my wolf soul for ever and for aye."

Now, we English pride ourselves on our power of self-criticism, especially in imperial matters; but I know of no British imperialist poet in any age who reveals a higher recognition of the responsibilities of empire than these poets of Portugal. I have quoted them here to show that, in so far as empire is trusteeship, the spirit of Portugal is not unworthy of colonial power.

It was not until the maritime factor in exploration became dominant over the military that the age of chivalry began to merge into

the age of discovery, and crusading into colonising. And for the age of discovery Portugal was as well-equipped. For the mixed coastal population of Portugal, with strains of Carthaginian Greek, Norse, English and Dutch stock, supplied suitable captains and crews for the carrying out of the imperialist policy of an Anglo-Portuguese dynasty that originated, at the opportune moment, from the marriage of John of Aviz with Philippa, daughter of John of Gaunt. John of Aviz owed his throne to the English alliance, to antagonism to Spain, and to popular support. His dynasty having no basis either in legitimacy or in landownership, he had to raise public revenues for himself without arousing popular resentment. His position was like that of a squire who has succeeded to a big place and position without the property to keep it up, and so has to take to business. John's new business was that of foreign enterprise and empire, which provided new and easily taxable values. His sons carried it on between them, Prince Henry the Navigator taking over the technical side and founding Portuguese colonial power by formulating the science of navigation. This very English type of scientific nobleman, working in his remote laboratory on Cape Sagres, contributed to the age of discovery its first essentials—a ship that could sail the high seas without being swamped, and the courage, the capital, and the co-ordinated effort that then, as now, constitute the art of empire-building. He was no swashbuckling sea-rover—indeed, he was much more like that friend of our youth—

> . . . The old lady of Portugal,
> Whose ideas were excessively nautical,
> Who climbed up a tree
> To examine the sea,
> But thought she would never leave Portugal.

But what he did was to open up to the energies of the western world, pent up between the Ottoman Empire and the Western Ocean, the two lines—one upon the African coast and the other across the Atlantic—upon which the West might again get in touch with the East. By this he not only reopened the Old World, but revealed the New, for Columbus was merely carrying out his conception like any other of the sea-captains he inspired. Portugal indeed lost the crowning prize—the discovery of America—by the accident that the Portuguese King, to whom Columbus applied, had abandoned Prince Henry's line of advance south about round the Cape of Good Hope and overseas across the Atlantic, for futile exploration north about round the North Cape and overland across Africa. So he only referred Columbus to an expert commission, who, of course, took up his idea and turned down the author. Equally naturally, the captain they sent out soon lost courage and came back, while Columbus carried out Prince Henry's idea for Portugal's rival—Spain. In the same way Portugal lost to Spain the services of the Portuguese Magalhaens, and the honour of first circumnavigating the globe.

If, however, the Portuguese owed their colonial power partly to their ancient antagonists the Turks, and partly to their ancient allies the English, they developed that power very much on their own lines. Their proceedings, both in gaining and in losing this power, are very instructive to us; for in this, as in many other of the great political movements, Portugal has been a pioneer to Europe.

How was it, then, that the Portuguese, who had so good a start in the race for Empire, have now dropped so far behind? Why did empire-building so exhaust them that they could no longer hold their own walls against Alva and Spanish militarism, whereas it gave us strength and skill to hold the seas against the Armada? The answer is that the Portuguese were by race crusaders and missionaries; we colonisers and merchants. They were proselytising for the Church; we prospecting for chartered companies. This difference was partly due to temperament, partly to the times; for the reign of the middle class, under which our Empire was built, had not begun. The consequence was that when the wealth of the Old World and the New began to pour into Lisbon, neither the Court, where the English element had become insignificant, nor the Church, nor the upper class, could do any good with it. Nor would they let anyone else put it to profitable use. When the Jews began to control it, and make Lisbon what London afterwards became under similar conditions, the Church ruined Portugal by persecuting them. Just as, later, when the Jesuits began to control the commerce of the empire, their system was broken up by the Crown and Pombal. In a word the Portuguese Empire at first had no business basis. We and others profited by Portugal's crusades against the obscurantism of Islam that barred us from the East, and the obscurity of ignorance that blinded us to the West.

Coming next to the question as to what constitutes the colonial power of Portugal, we find that it was from the first divided into three distinct and very different developments. These

correspond to their colonising enterprises in the three continents, Asia, America, and Africa, each of which had a different character and a different course. The Asiatic empire was, broadly speaking, aristocratic; the American, democratic; the African, bureaucratic. Portugal in Asia has died of disease and decay; Portugal in America has grown to giant size, but has for a century gone off on its own; Portugal in Africa is still in an infancy as full of promise as of problems. Therefore, in a moral sense, Portuguese colonial power to-day consists of the historical relics of Portugal in Asia, the cultural relationship with Portugal in South America, and the material resources of Portugal in Africa. Strictly speaking, Portuguese colonial power comprises, in Africa, the great undeveloped possibilities of Angola and Mozambique and the highly-developed cocoa islands; in Asia, Goa and some other settlements that are dead, Macao that is dormant, and the island of Timor that is undeveloped. The rest are insignificant. Madeira and the Azores are practically Portugal.

Of the three developments in Asia, America, and Africa, by far the most brilliant was the brief blaze of glory in which the Portuguese Empire in India burnt itself out. "Golden Goa" was a characteristic product of the brief and brilliant "Golden Age" of Portugal. In its best aspects it was also an anticipation of our Indian Empire. The prototypes of our great proconsuls were Portuguese noblemen like Albuquerque and Noronha. Types of chivalrous soldiers like Outram and Gordon are as easy to parallel in the history of Portuguese India; for in the age of chivalry Portugal was among the first of all European peoples. We may recall, in passing, that the ladies of the Court of Edward III. asked for twelve Portuguese knights to teach the English manners. And as the common soldier replaced in importance the cavalier, Portuguese infantry were again among the first. Let me call in evidence the "Iron Duke" himself, no admirer of foreigners, who towards the end of the Peninsular War brigaded Portuguese infantry with the famous Light Division as their equals. For such leaders and such troops the conquest of India seemed a certainty. The first fruits of that conquest had, indeed, in a few years made Lisbon the most splendid Court in Europe, and likely to become the capital of the civilised world. But the whole splendid structure was rotten, and its gilded cupolas and soaring pinnacles had no foundation. It was predatory and parasitic, with no real life of its own; it became mere priest-ridden profiteering, corrupting everything with which it came in contact. From a crusade for the national ideals of Portugal, it became a conspiracy against those ideals. Like an evil incubus it drained the vigour of Portugal, and in return demoralised it with its gold and jewels. And so to-day the Portuguese power in India survives only in a few enclaves on the map of British India, with names known only to history, and a few Eurasians in the middle class with names that once were known throughout Christendom.

In this last feature we find a suggestion of another reason why the Portuguese Indian Empire failed. One was that it became rotten through having only a parasitic vitality; the other was that it allowed the native stock on which it was grafted to sap the imported culture. The Portuguese Indian Empire, like ours, was based on the rule of a caste apart, and this required respect for the colour line. But the policy of the colour line is as repugnant to Portuguese philanthropy, to their instinctive humanity, as is slavery to ours. In other words, their humanity is personal; ours predial. They look on a native as an inferior fellow-man; we as a superior foreign mammal. Either point of view has both its advantages and its disadvantages for both the dominant white and the dominated coloured race; but the Portuguese policy of intermarriage is as clearly incompatible with the principle of caste government as ours is unconformable to the principle of co-operative government. The Portuguese lost India because they were too racially democratic to be rigidly aristocratic. If we ever lose India, it will be because we are too rigidly aristocratic to admit of any real democracy.

In the Portuguese Empire in America, now the United States of Brazil, we have a Colonial Power that was in the opposite extreme. Both its genesis and exodus, so to say, were democratic—even more democratic than our colonial system in North America. The result of this absolute democracy of the Brazils was, in the first place, no war of extermination with the native Indians; in the second place, no external war of independence between the American democracy and the European aristocracy; and in the third place, no internal civil war between the aristocracy of the colonies and their democracy. The crusading element in this Portuguese enterprise took a missionary and not a militarist form, and was represented by the Jesuit missions. Whatever we may think of the work

of the Society in South Europe, there can be no two opinions as to their work for humanity in South America. Thanks to them, the whole imported culture has been so grafted on the native stock that the South American of the future will not be merely a new Portuguese, a revised edition of a North European, but a Eur-American, with potentialities as vast as those of his territories. The world's future in music, art, and literature may well lie with the children of Portuguese culture in the Brazils.

The vitality of this Portuguese colony, both as a colony and as Portuguese, contrasts curiously in both respects with that of the Indian colony. The Indian colonies, when Spain conquered Portugal, became Spanish automatically. But when the Brazils were sacrificed by Spain to the Dutch to save Spanish possessions, the colonists resisted successfully all attempts to alienate them from Portugal, and returned to their allegiance at the first opportunity. Moreover, it was the tribute from Brazil that enabled the Braganzas, after the restoration, to throw off the Spanish rule, and also, unfortunately, to throw over the Portuguese reformers and govern for two centuries as absolute monarchs. The result of this last was that the tie became merely dynastic, and when the Portuguese monarchy fell under the strain of the Napoleonic wars, Brazil became automatically independent. The United States of Brazil, like those of North America, owe their separation to a misuse by the mother-people of the monarchical principle.

In Portuguese politics Brazil has played an important part. As when Pedro, Emperor of Brazil, came over to put an end to the reactionary despotism of his brother Miguel, or when Brazil, after becoming a republic, contributed to the present renascence in Portugal by supporting the Republican Revolution.

In Portuguese economics the contribution of Brazil has been very considerable, owing to the fact that in the Portuguese economic balance-sheet the remittances from Brazilian emigrants count for as much as one-half of the total incomings. Portugal itself produces little, purchasing much of its food abroad, and pays heavy interest on a disproportionate debt, two-thirds of the proceeds of which have been wasted. To pay for all this, Portugal must export something, and has nothing but the produce of its African colonies and the population of its own countryside. This enforced emigration has been particularly ruinous to Portugal, and the Republican reformers are pledged to remedy it. It was, indeed, one of the causes of the Revolution, and Guerro Junqueiro, the revolutionary poet, finds in it a subject for the *sæva indignatio* that made his poems a political power. It must be remedied before there can be any return of prosperity to Portugal itself and any real reconstruction of the African Empire.

There remains, then, to Portugal this African Empire, the vast tracts of territory that were Portugal's founders' shares in the European flotation of Africa. Until quite lately these colonies were only a financial and political embarrassment, and under the monarchy the proposal to trade them off against the burden of debt found favour. The Republican reformers rejected this as treason, and their view has since found practical justification. For there has been a considerable and increasing contribution to the economic balance-sheet from the control retained by Lisbon of the produce of these colonies, notably the cocoa islands. But the Republican reformers, in their task of making the Portuguese Empire pay, have had formidable difficulties to contend with. The first dilemma was that between colonial secession if the mercantile system and central administration from Lisbon were retained, and loss of all profits if it were abandoned. This has been dealt with by a generous grant of self-government, while control of colonial produce is retained by customs regulations.

Then came the difficulty that the colonies could only be exploited by native labour, and this caused trouble with the natives and with foreign philanthropists. This has been met by a regulation of native rights and of conditions of contract labour that works well and has been generally recognised as satisfactory.

Thirdly, the worst dilemma was that Portugal had neither the money-power nor the man-power to develop the vast resources of these regions quickly enough to satisfy the demand for their raw materials. Before the war it looked as though such development would, with all outward observance of Portugal's eminent domain, be taken over by other Powers. This situation has now been simplified by the participation of Portugal in the war. Whatever the future of the Portuguese colonial power in Africa may be, it will only now be fulfilled with the full approval of the Portuguese people.

Finally, we have to find an answer to the question what contribution can Portuguese colonial power make for good or ill to our reconstruction of civilisation.

There seem to me to be two possible principles of peacemaking. One, restoration as far as

possible of the *status quo ante bellum;* the other, reconstruction. We should all prefer the latter, and in respect at least of the future status of Africa we shall be in a position to impose it. Nor shall we, to judge from the latest Prussian pronouncements, encounter much opposition from them if we use our power in the general international interest, and not exclusively in our own imperial interest.

But let us suppose that conditions elsewhere impose on the Allies an African settlement that is rather a restoration than a reconstruction. In that event the contribution of Portuguese colonial power will not be for the good either of Portugal or of Europe. Portugal will indeed, by participation in the war, have improved its *ante-bellum* position so far as concerns protection of its possessions by the Allies, but this protection can only operate in so far as war conditions continue or can be recommenced; for the peace basis of Portugal's possessions was the counterpoise between British and German economic and political interest in them—a counterpoise in which the conservative interest of Great Britain counter-balanced the covetous intentions of Germany. Just before the war this balance had been upset economically and politically, both as regards the colonies themselves and their controlling centre in Lisbon. The deadlock between the rival interests of the Great Powers had been replaced by a delimitation of economic interest in the African territories. It looked as though the Portuguese possessions might have to exchange the agreeable *rôle* of a *tertius gaudens* for that of a *tertium quid.* But more was involved than Portugal's immediate loss of economic control, and ultimate loss of political control, of these colonies. We have seen how important the profits from colonial produce are to the mother-country. Now, the natural market for this produce was, before the war, and will be after it, in Germany. The natural money centre for financing this production would be Lisbon. But Lisbon has neither the capital nor the credit even for financing the existing exploitations, still less for floating new enterprises. Consequently financing operations have passed to the only other parties interested, the German consumers, and are mainly in the hands of German firms in Lisbon. But these operations, being by far the most important financial business in Lisbon, have tended to carry with them not only considerable control over economic developments in the colonies, but also over the economic existence of the capital. And where there is economic control there is an essential element of political control. Before the war German business enterprise, both private and public, had made considerable progress towards supplanting British trade in its secular pre-eminence in Portugal. Courage, capital, and co-ordinated effort are the essentials of the art of empire-building, by whomsoever they are exercised.

If, therefore, the principle of the settlement in respect of Portugal and its possessions is restoration, and not reconstruction, we shall find this process resumed. In that case, Germany may—indeed, Germany must—continue the economic penetration of Portugal and its possessions to its inevitable conclusion in German political predominance over both the home country and the colonies. Recent events suggest that this process will be prosecuted by a restoration of the monarchy under a German prince and a reversionary interest in the colonies in return for relief from debt. We may recall that under the late monarchy there were serious proposals to sell some of the colonies, including Goa, to Germany, and that the Republicans are pro-British; the Royalists, with the exception of some "Manoelists," are pro-German. Should Portugal become a Germanophil Principality, and its possessions Germanic protectorates, the map shows us what this would mean to the prospects of peace for us English. To us, as Europeans, it would mean the permanent partition of Europe into two armed camps, and the permanent partition of Africa into two or more colonial cartels. The integral independence of Portugal is only one degree less vital to us than that of Belgium. The future of Africa is involved in that of the Portuguese colonies.

We should, no doubt, combat this course of events by political and economic action. By instituting a trade bank at Lisbon, by sending out trade commissioners, and by increasing transport facilities we could do much, and we have previous failures in such efforts to profit by. But in case of a settlement by restoration only, the contribution from Portuguese colonial power will be mainly to present us with some very difficult problems.

Now, therefore, let us take the other alternative —that of reconstruction on a more or less international basis. The European exploitation of Africa has always had both an imperial and an international character. Its main function, that of supplying Europe with raw material in return for capital and control, is essentially international. But as competition for such

control increased, first the administration and then the exploitation of Africa was partitioned into imperial protectorates and parcelled off into preserves of the Great Powers. Their Governments did not sufficiently represent the social entity and economic solidarity of Europe, and the international element of the European exploitation was not expressed in institutions, or where it was so expressed, as in the Congo Free State, it was allowed to lapse.

But one result of this war—if it is, as all sides say, a crusade for civilisation—will be a movement to reconstitute and reinforce the common interest of civilisation by various international institutions. In Europe the international interest will be expressed in some form of *confederate* authority, such as the League of Nations. In Africa, by some form of *federal* authority. This federal authority, while recognising the existing administrations and annexations, would co-ordinate and control them in the international interest of free trade for all nations and fair play for all natives. The colonial power of Great Britain, France, Portugal, and Germany must all contribute towards the establishment of a Colonial Power of Europe.

Such a reconstruction on an international instead of a national basis removes or relieves all difficulties—the difficulty of Portugal in developing its possessions without being deprived of them; our difficulty in defending Portugal and its possessions without raising a "war after war" or risking another "war to end war"; the German difficulty of getting enough colonial produce without having enough colonial power: the European difficulty in preserving peace and protecting the natives.

Can we on such conditions count on Portugal's readiness to make this contribution? In view of the fact that Portugal could scarcely meet the charges on its foreign debt if it renounced the revenues from colonial produce, it would be proper that a compensating relief from debt should be arranged by the new federal authority for Africa as an African national debt. And if in terms of territorial area the contribution of Portugal to the new federation would be rather more considerable, say, than ours, yet the benefits accruing would be correspondingly greater; for the security of investment that would result from the federal regulation of exploitation would enable Portugal to develop its colonies without mortgaging them to any other Power. For a policy of internationalism that would save Central Africa from German or any other imperialism, we can count on the contribution of the Portuguese Republic with confidence.

It is on this note of confidence that I would close this consideration of Portuguese colonial power by quoting from the poet-president of the Republic, Dr. Braga. After reviewing the services to humanity of the great world empires, he defines the contribution of Portugal thus:—

And with what arms shall Portugal engage,
So little as she is, in such great feats?
They count on her to take a leading part
Who know that in the Lusitanian heart
Love beats.

DISCUSSION.

Major E. H. M. Leggett, R.E., D.S.O., in opening the discussion, said some might have thought that a note of sadness ran through at any rate the first part of the paper, which seemed to be a kind of requiem of the past glories of a great imperial people, but the author went on to analyse the reasons for that, and at the conclusion of the paper he used the words: "I end upon a note of confidence." There was one point that the author had not developed, and that might be taken as having run through all the four papers which had been read before the Colonial Section of the Society on the African Possessions of the Allies, and that was the common ideal which actuated the four great Allied African Powers of to-day: the sense of trusteeship towards the native, the conviction that development to be sound, permanent, and profitable in the best sense to all concerned must be founded on a just policy towards the native, who must have as large a share in the profits of that development as the controlling European Powers. That was the point that differentiated the African policy of the Allies from that of Germany, whose policy in Africa was founded upon militarism and upon *quasi*-slavery. Germany looked upon the African native as a hewer of wood and drawer of water for the benefit of the controlling white Power. When the author came to his final suggestion of the reconstruction of Africa and discussed it on the lines of internationalisation, he could not help feeling that before such a reconstruction into which Germany could be admitted was possible, there must be an absolute end of the German policy towards the African races. But was Germany likely to adopt any change in her policy? Only last week the German Colonial Secretary stated that the aim of the Imperial German Government was to regain the colonial possessions of Germany and to develop them into a strong and economically productive whole, that there must be a just redistribution of the colonial possessions of all nations in Africa, and that the standard for that redistribution must be, from the point of view of power, the ratio of the physical strength of the States concerned. "Power"—not trusteeship. Power for the drawing of the economic products of Africa to the benefit of the European comity of nations? Not at all, but solely for Germany. If German

militarism was not defeated that country would extend its rule from the Zambesi to the Sahara, and the colonies of Portugal, Great Britain, Belgium and France would disappear. It must never be forgotten how radically the policy of Germany towards Africa, and towards its indigenous populations, differed from that of the Allied Powers towards the same.

MR. JOHN H. HARRIS thought that in the reconstruction of the African continent the main factor would be that of considering the reconstruction of our treatment of the native races. After all, the German colonies would be of very little use to Germany if they were restored, unless some means were found for providing those territories with the necessary population. In the part of Africa known before the war as German South-West Africa, the population was so sparse that there were actually three square miles to every native, and in Togoland the population had been reduced during the last thirty years from 2,500,000 to 1,500,000. The same problem confronted Portugal to a very considerable extent. The economic success of the cocoa islands was very pronounced, but that success was after all only maintained by a continuous importation of labour. In all colonial industries some means must be found for the provision of adequate supplies of labour, and it was remarkable how much could be done in that connection by very careful attention to the health and the general conditions of the labourers. The death-rate of the natives employed in the mines of the Rand had now been reduced to something like twelve per 1,000, which was a very great reduction from the heavy death-rate of former times. Some people were beginning to wonder whether the time had not arrived to associate the natives of Africa much more closely with the industries of the Continent. During the last fifty years there had been a very remarkable development amongst the natives themselves; in West Africa to-day there was a considerable number of natives of quite substantial means, some of them receiving salaries or incomes of from £500 to £1,000 a year. The fact that they were assuming important positions in Africa seemed to point to the necessity of providing them with some means of investment more ethical than a plurality of wives and more economically sound than a redundancy of cattle. Many people were now seriously considering those two points—whether in the reconstruction of Africa a better distribution of the native population could be secured, and a closer alliance between African labour and African industries. In Portuguese territories probably as good opportunities would be found for carrying out those ideas as in the colonies of other Powers, particularly in view of the fact, to which the author had drawn attention, that there was less of the colour prejudice in Portuguese colonies than was to be found in the colonies of any other Continental Power.

SIR FREDERIC S. P. LELY, K.C.I.E., C.S.I., in proposing a vote of thanks to the author, said the subject of Portugal was an extremely interesting one. He had been greatly struck by the comparison between the vitality of Brazil on the one hand, and what he was afraid was only too justly called the degeneration of the Portuguese national character and position in India. Personally he had had Portuguese for his neighbours in India, and he had very pleasant recollections of his intercourse with them, and was not prepared to admit that there was no future before them in that country. There was no doubt that India had owed something to the Portuguese in the past. At the present moment the only benefit he could remember that the Portuguese had conferred upon India was the improvement of the mango, the Portuguese being very expert gardeners. He thought their two main defects in India were that their civil government was too much confused with religious propaganda, and that they were too completely severed from their own homeland. He hoped that, in the rearrangement of the world that would take place after the war, Portugal would play a great part in happy alliance with this country. One very suggestive point had already been alluded to, namely, the extraordinarily different attitude adopted in Brazil towards the coloured races from that adopted, for instance, by the United States of America. Lord Bryce had stated that in Brazil there was absolutely no such thing as colour prejudice, and that the races mixed, even in marriage, in the most unrestricted way.

MR. BYRON BRENAN, C.M.G., seconded the motion, which was carried unanimously.

The meeting then terminated.

CASTOR-OIL PLANT.

Of late there has been considerable inquiry as to the cultivation of oil-yielding plants, including the castor oil. There is ample evidence that this plant will thrive almost anywhere on the coast lands of Queensland. In and around Brisbane, the *Queensland Agricultural Journal* states, it may be seen growing and bearing heavy crops of seed in all sorts of out-of-the-way places—on the river banks, in quarries, on unoccupied allotments, etc.; and this applies as well to other coastal localities in Central and North Queensland. No attention has, however, been given to it with a view to turning a plant which is looked upon almost as a noxious weed to profitable account. Most people, especially children, know to their sorrow that castor oil is a most valuable medicine; but not many are aware of the large quantities which are used for lubricating machinery and for illuminating purposes. In India it is used on all the railways in the signal and carriage lamps, owing to the brilliancy and safety of the light. It burns very slowly, and thus is more economical than other oils.

The plant is exceedingly hardy and will stand

a wide range of climate. The seeds have extraordinary vitality. Oil seeds, as a rule, quickly lose their germinating power; but the castor seed seems to be an exception. Seeds known to have been kept for fifteen years in a bottle have been sown in Queensland, and have produced healthy plants. In a tropical or even subtropical climate the plant becomes a perennial tree instead of an annual, attaining a height of from 20 to 30 ft. The best soil for castor is much the same as that required for the cotton plant—a rich, well-drained, sandy loam. It will not thrive on heavy, wet soils. As the roots penetrate very deeply, the land must be deeply ploughed and well worked. The seed is planted in rows 6 to 8 ft. apart each way, three or four seeds being planted in a hole Before planting they should be softened by having hot water poured over them, and then being left to soak for twenty-four hours. In ten days after sowing the seeds will germinate, and when the plants are 8 or 10 in. high the three weakest must be taken up where four seeds have been put in. They grow very rapidly, and begin to bear in four months. Like the coffee and cotton plants, the castor plant would grow to an inconvenient height if left to itself. It should, therefore, be kept low by pinching back the main stem. This will have the further effect of causing the plant to throw out many more fruit spikes than it otherwise would do. When the tree gets old, the usual scale insect (the *Coccus*) attacks the bark. They have to b dealt with, as in the case of citrus and other fruit trees, by spraying with kerosene emulsion.

When the capsules turn brown it is time to begin the harvest. This is done by cutting off the spikes and removing them as soon as possible to the barn. The work of harvesting must be done rapidly, for if the seeds are allowed to ripen on the tree the pods burst open and the liberated seeds fly in all directions. This "popping" of the capsules makes the matter of freeing the seeds a very simple one. All that has to be done is to prepare a drying-ground either in a shed or in the open. The ground should either be boarded or swept quite clean. When the spikes are brought in they should be spread out on the drying-ground to the depth of from 6 in. to 1 ft., according to the heat of the weather. Should rain occur when out-of-door drying is being carried on, draw the spikes into heaps and cover with a tarpaulin. Turn the spikes over frequently to let all get the benefit of the sun. The capsules will soon begin to burst, and in four or five days they will have shed all their seed. All that remains to be done is to sift or winnow out the husks. When drying in the open, it is well to surround the drying spikes with a low rampart of galvanised iron or bagging, for the reason that many seeds fly out very violently, and without some such precaution they would be lost.

The return from an acre is about 20 bushels, a bushel of seed weighing 46 lb.

In India the seed is crushed between rollers, placed in hempen cloths, and pressed, and then the oil is heated with water in a tin boiler until the water boils. This separates the mucilage and albumen, the product being finally strained through flannel.

Cheap wooden rollers would serve the purpose. and these could be driven by a horse gear.—*The Colonial Journal.*

RAILWAY SURVEYING IN CHINA.

The following statement regarding railway surveying in China, written by an expert, has been sent to his Government by the United States Consul-General at Shanghai :—

At the outset it must be realised that, with the exception of the coast-line and the great navigable rivers, there are no accurate maps. Consequently, when it is proposed to build a railway between two definite places it is frequently the case that the intermediate country is as unknown as if it were in the remotest parts of Central Africa. The two main considerations in designing a railway are straightness and levelness. The latter is in many ways more important than the former, since a steep road requires more powerful locomotives and is therefore more expensive to run.

The work of surveying usually proceeds in several stages. First of all there is a reconnaissance. An experienced engineer walks or rides over the country between the two places and explores every possible route. By noticing the times required to traverse short lengths (say. five miles or so) and the magnetic bearing of such short lengths, he obtains a rough idea of the distance, and by means of a barometer he observes the heights of the mountain passes or ridges over which the line may pass.

The responsibilities of this part of the work are very serious, because the engineer must usually decide on the abandonment of certain routes, and in many cases it is difficult, with the information at his disposal, for him to feel sure that his choice of route or routes is the wisest. He must possess great powers of judgment and also experience in similar work to know .f the economic and engineering peculiarities of a certain route warrant its further consideration.

The work is also arduous, since he must walk or ride twenty or more miles per day, personally examine every possible position, and be prepared to camp almost anywhe e.

The next stage is the preliminary survey, and is a much more elaborate process. The reconnaissance having shown which routes need to be more carefully investigated, a regular survey is made along the lines laid down on the small-scale, rough maps prepared by the exploring engineer. This is generally done by one or more

parties, consisting of a chief of party, one or more assistant engineers, several surveyors (generally Chinese students), and numerous survey coolies.

The chief of the party goes in front and makes a more detailed study along ten to thirty miles of the route indicated by the reconnaissance, and returns personally or sends word to the chief assistant as to details to be observed. He himself, or one of his assistants, then proceeds to fix pegs from 100 to 1,000 yards apart, between which lines can be measured with a chain. By means of a theodolite or transit the direction of these lines is observed.

The domestic arrangements of a survey party are very similar to those of the exploring engineer, except that the survey advances with much less speed (rarely more than five miles a day), so that it is not necessary to move camp every day. On the other hand, a difficulty occurs from the very size of the party. There may be, including carrying coolies, more than one hundred persons, and it is not always easy to secure accommodation for so many, especially in the less densely populated parts of the country. On account of the great expense and the desirability of speed, the working hours are from sunrise to sunset.

Trees and undergrowth must be cut away along the line so as to allow it to be chained, and measurements taken. Sometimes it happens that the line passes along the steeply sloping side of a hill, and then, on account of a projecting spur, rises suddenly up and falls again, so that a small element of danger is present.

When this survey has been completed, the final position of the railway may be chosen and drawn on the plan. Estimates as to the cost of filling in and cutting out, building bridges, etc., can be made, and it will then usually be decided whether to proceed further or not. If it is decided to proceed, the next step is to "locate" the line, which means to peg out the exact centre line. This is still more tedious than the preliminary survey, since the line must be followed, no matter where it goes.

SHANTUNG WOOL.

The following synopsis of a report on Shantung wool, prepared by the Imperial Japanese Military Administration of Tsingtau, has been sent to his Government by the United States Consul at Tsingtau :—

Wool in China is produced chiefly in Mongolia and North China. While the quality of Chinese wool may not equal the Australian product, the greatly augmented demand at present has caused an increased export, especially to Japan. Shantung Province is one of the principal wool-producing regions of North China. Shantung wool is commonly classified as "spring" and "autumn" wool, depending upon the time of shearing, and into "fleece" and "raked" (literal translation of Japanese terms) wool, according to whether it is sheared or raked from the sheep. There is produced and exported, also, a relatively small amount of goat's hair, in quality superior to sheep's wool—that is, raked from the goat's back in the spring.

Owing to the method of caring for the wool and the character of the wool itself, Chinese wool is used only for coarse articles like carpets and blankets. Probably 1,300,000 lb. of wool are produced annually in Shantung, of which one-fifth is consumed locally and four-fifths exported through Tientsin and Tsingtau. In addition to this amount, outside wool to the extent of about 250,000 lb. is brought into the province for sale. The wool is collected in the interior through brokerage houses, who charge 3 per cent. commission. Sometimes purchases are made direct from producers, either when the wool is displayed for sale or by forward contract.

THE SWISS CHEMICAL INDUSTRY.

According to the annual report of the Basle Chamber of Commerce, the Swiss dye industry views with great concern the rise of a dye-manufacturing industry in other countries, particularly in England and America. It was thought at first that the development of such an industry in other countries would be seriously handicapped by lack of the cumulative experience and inherited skill of many years, but, owing to the fact that Swiss chemists have in many cases offered their services, this industry has already made great strides in the countries named. The report states that in America especially dye factories have sprung up like mushrooms, and there is already danger of over-production and consequent disaster. Reference is made to British Dyes, Ltd., in England, and also to the French company. The prospect of establishing a dye industry in Italy is not considered bright.

In regard to acids, the report goes on to say that the greater part of the production of hydrochloric, sulphuric, and nitric acids is required for the manufacture of munitions in Switzerland, so that there is a great scarcity of these acids for other purposes. A new sulphuric acid factory is, however, being erected in Schweizerhalle. Also the new Swiss soda factory at Zurzach was able to commence manufacture in August, 1916, although the output is at present very small.

The supply of raw materials from England and America is gradually becoming less, and the difficulties of the Swiss chemical industry are correspondingly greater. But the greatest difficulty of all is the prospect of a coal famine, especially in view of the fact that the supplies of substitutes such as wood and peat are not very plentiful. The manufacture of artificial indigo is now very seriously handicapped in Switzerland owing to the lack of raw material.

ENGINEERING NOTES.

An American Submarine Boat Yard.—The *Engineering News Record* gives a detailed account of the submarine shipyard in New Jersey, U.S.A. The yard occupies about 125 acres at the southerly end of the new Port of Newark Terminal. This terminal, belonging to the Submarine Boat Corporation, has been under construction for a few years past. It comprised, when taken over for shipbuilding last August, a flat sand fill some 5 ft. above high water in Newark Bay, with a parallel frontage of about 2,700 ft. on the bay, where the depth of water at present is 12 ft., and extending back about 1,800 ft., with a channel on one side. The site is about four miles from the City Hall of Newark. The whole area has city sewer and water connections. A bulkhead dock-wall exists alongside the property. In this yard will be built, according to present plans, one hundred and fifty 5,000-ton boats. The entire plant is to get its power from local electric power companies, between 9,000 and 13,000 h.p. being the estimated power required. The compressor houses and transformer for the shipways will be located in small houses between every fourth set of ways, there being seven such houses to the yard.

Improving Cast-iron with Uranium.—By alloying uranium with cast-iron or semi-steel, the strength and toughness of the metal is increased, as well as the fluidity, according to a patent (U.S.) says the *Iron Age*. The quality of the iron for machinery is claimed to be enhanced and the resistance to wear increased. The new alloy is made by adding uranium to the molten iron as uranium metal, or ferro-uranium, so that the finished product will contain from 0·05 per cent. to 0·10 per cent. of uranium. The addition of this element is said to deoxidise and denitrogenise the metal, increasing the tensile strength and producing a fine grained product.

Water-power in Tasmania.—"When the electrolytic zinc works at Risden," says Mr. J. H. Butters, the Chief Engineer and Manager of the Hydro-Electric Department of Tasmania, "are ready to take their first instalment of electrical energy—4,000 h.p.—which will be in a few months, the Tasmanian hydro-electric scheme will be loaded up to its full present capacity of 10,000 h.p. We are preparing to increase the capacity to 30,000 h.p., but just at present it is impossible to secure the material for the steel pipe-line. That the Great Lake can give us the water for 30,000 h.p. is a matter that admits of no doubt. All my estimates have been based on a conservation of enough water in the lake to give 35,000 h.p., but for a long time past enough water has been flowing out of the lake to give us twice that, or 70,000 h.p., if we had the machinery to develop it. The surveys relating to the proposal to harness the King River to supply the 20,000 h.p., which the Mount Lyell Company desires to use in the work of treating the complex zinciferous ores of the Read-Rosebery group have been completed. The designs for the work are now being drawn up, and will be submitted to the State Parliament during the coming session. If Parliament approves of them, we shall be able to go straight ahead with this work."

Conversion of Sawdust into Gas.—With the object of effecting a further reduction in the transit and use of anthracite coal for gas-making for gas engines, Mr. W. T. Crampton, M.Inst.M.E., suggests, in the *Daily Telegraph*, the value of suction gas. For the conversion of sawdust into gas, the plant is slightly larger than for coal, and with the use of a tar extractor, the principle is the same. The possibility of the use of this waste is not generally known, and consequently the volume of sawdust destroyed and wasted is serious.

Steaming Capacity of Locomotive Boilers.—A writer in the columns of an American engineering contemporary, says the *Railway Gazette*, lays down some rules the observance of which would, he states, ensure superior steaming qualities in locomotive boilers. Every engine should have as large a nozzle as it is possible to use, and thus enable the engine to make steam freely. If an engine is failing for steam, the nozzle should not be reduced until full investigation has been made, in order to determine whether or not the engine has any other defects which might in any way contribute to the failure. It is necessary that all joints around the front end should be kept absolutely airtight, and that the area of opening in the front end netting be as large as possible. The air opening in the ashpan should not be less than 14 per cent. of the grate area and 100 per cent. of the tube area. Insufficient air opening will probably make it necessary to operate the engine with a reduced nozzle opening. A reduction of from $\frac{1}{8}$ to $\frac{1}{4}$ in. in the size of the nozzle might easily cause a waste of from 2,000 to 4,000 lb. of coal per trip over the average division. Leaky steam-pipes or nozzle-stand joints will cause a waste of 2,000 to 4,000 lb. of coal per trip. Steam pipes should be tested every time an engine is held in for repairs as long as two days or more.

The First Large Concrete Ship.—Last August the San Francisco Shipbuilding Company began the construction, at Redwood City, California, of the ways for the building of a reinforced concrete ship of 7,900 tons displacement, with a deadweight carrying capacity of 5,000 tons. The laying down of the ship was started in September, and the vessel was to be ready for launching on March 1st. Had it not been for changes of plans and the employment of a new naval architect, the vessel would probably have been ready for the water on February 1st. The ship is 336 ft. long over all, 45 ft. in beam, and 31 ft. deep to the upper deck. The draught loaded will be 24 ft. The ship will be equipped with Scotch marine boilers and 1,750 h.p. triple-expansion engines. The speed, according to the *Engineering News-*

Record, will be ten knots. The company now has under way designs for four ships of 7,500 tons dead-weight carrying capacity.

Generating Steam with Electrical Energy.—The Swiss Society of Steam Boiler Owners has carried out tests on the commercial possibilities of generating steam with electricity derived from water-power. A small boiler was used with thirty-eight steel tubes, in thirty-four of which were placed heating coils. An evaporation of 2½ lb. of water per square foot of heating surface was obtained, and the efficiency was 90 to 91 per cent. To compete with coal in Switzerland, at 44*s*. per ton, the cost of energy would have to be not more than 0·08*d*. per unit. Owing to the scarcity of coal, which now costs over £3 a ton, and is likely to reach £4, the working of the Swiss railways is costly and difficult, and the feasibility of using electric heating on steam locomotives is being seriously considered. While the complete electrification of the railways cannot be accomplished at present, the supply of electricity to the locomotives would present less difficulty, and the cost of energy from water-power would be only 0·15*d*. per unit, which would be comparable with the cost of coal. In view of the possibility that the supply of coal from Germany may be completely stopped, the subject is of some importance to the railways, which would have no alternative in such an emergency.

A Long Continuous Girder.—In America, where they often do large things, they have just completed the Sciotoville Bridge, over the Ohio River, which is the largest continuous work of the kind on record, being 775 ft. span. The subject of this method of construction was discussed by the Society of Engineers, as recorded in our notes on May 11th last. The continuous beam is not usual in bridge work for road or railway purposes, for the reason that there is an amount of uncertainty about the position of the point of contrary flexure, as it is called, owing to the live load, as against the dead load, which only has a fixture of one-fourth of the distance from the piers. However, the bridges on the Madras Railway, on the comparatively moderate spans of double 70 feet, were fixed many years ago on that principle, and several remain so still, though some of them were superseded by greater flood openings, due to other causes than to the continuous theory. The uncertainty about the position of contrary flexure was solved by the approximate and safe provision of sufficient metal, and the object of the arrangement was to enable the girders to be rolled over two or more piers from the abutments; hence the avoidance of the expense, and risk from flood, of staging.

OBITUARY.

KENNETH J. CAMERON.—Information has been received of the death from pneumonia of Mr. Kenneth J. Cameron, which took place on November 18th at Zomba. He belonged to the Nyasaland Volunteer Reserve, and was attached to the South African Engineers, who were engaged in keeping up road communication between Railhead and Lake Nyasa.

Mr. Cameron was born at Lochaber in 1862. He worked for some years at the Royal Botanic Gardens, Edinburgh, and at the same time studied at the School of Art, where he obtained his Art Teacher's certificate. In 1890 he accepted a five-year engagement under the African Lakes Company, Ltd., and at the termination of this he started as a coffee-planter on his own account. He made a careful study of various insect pests, and he also experimented in growing cotton, tobacco and indigo.

He was elected a member of the Royal Society of Arts in 1901.

VICE-ADMIRAL WILLIAM USBORNE MOORE.—The death is reported at Southsea of Vice-Admiral William Usborne Moore, who had been a member of the Royal Society of Arts since 1891. Born in 1849, he entered the "Britannia" in 1862; in the following year he joined H.M.S. "Revenge," and subsequently served as assistant surveyor on H.M. ships "Newport" and "Sheerwater." He was then selected to take charge of a survey of the Fiji Islands, which occupied him for five years. From 1882 to 1885 he commanded the "Dart" on the Australian station, and acted as Deputy Commissioner of the Western Pacific. In 1885 he was promoted commander and proceeded to the China station. He obtained his captaincy in 1892, and three years later was given the home survey on board H.M.S. "Research." For nearly twenty-five years he was in charge of surveys at home and abroad, the triangulation along the coast of China for many hundreds of miles being one of his most notable achievements.

NOTES ON BOOKS.

A POCKET HANDBOOK OF MINERALS. By G. Montague. Second Edition. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. 11*s*. 6*d*. net.

A pocket book or field book comprising somewhat over three hundred pages, and conveniently bound in limp covers, is here presented to the reader.

The preface is, to a considerable extent, a laudation of the book, and, *inter alia*, we are told that "nothing is herein included which may not be needed in the pursuit of the end for which the book was prepared—*i.e.* the determination of minerals." Turning to mercury—which, as a mineral, occurs in minute fluid drops in a rock-like gangue—the student is taught to identify the metal by the streak, "Tin-white when solid," and the cleavage "Perfect cubic when solid."

If there is a fault in the book it is the sacrifice of practice and real science to a system: streak

and cleavage are frequently or generally of importance, hence they are unduly introduced. Further, in reference to diamonds, under the heading, "Streak," we find "None," which rather reminds one of the story of a newspaper's stop-press news, "We stop the press to say there is no further news." To make "Halite" the main heading for rock salt, and "Cerargyrite" the main heading for hornsilver, suggests perhaps an over-devotion to the termination "-ite". Again, "Smithsonite" (p. 117) does not appear to us a very desirable leading term to replace the ancient calamine: still, the general scheme of the book is good, and with careful editing and better photographic illustrations, future editions may be much improved. Minerals give very full and good return for real skill in photography.

Microscopical Determination of the Opaque Minerals, as an Aid to the Study of Ores. By Joseph Murdoch, Ph.D., Geologist, Secondary Enrichment Investigation. First Edition. First Thousand. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. 1916. 9*s.* 6*d.* net.

In the present volume the student will find a thoroughly well-laboured conspectus of that aspect of mineralogical research which corresponds to what is now known as metallography, and also to petrography; an aspect which the author appropriately terms "mineralography," and it may be that in future editions this concise term may be the leading title of the book, the present title then falling into place as a sub-title, or explanatory title.

"Mineralography"—if we may adopt and endorse our author's suggestion—is the art of judging of "opaque metalliferous minerals" by a study of a polished flat surface, while metallography is a comparable study of the reduced metals or their alloys. Petrography, on the other hand, involves the use of thin and more or less transparent sections of rocks which are not metalliferous in the broad and industrial sense, as distinguished from the more recondite chemical aspect.

We may, perhaps, put it rather emphatically that any person entering upon a serious study of mineralography will scarcely find any alternative to obtaining the work under notice, and in saying this we are perhaps giving the highest praise in our power to Dr. Murdoch's treatise.

It is to be clearly understood that Dr. Murdoch in no way claims to have originated that branch of technical discrimination or analysis of which he treats, as, like all worthy investigators and pioneers, he gives the fullest credit to those who have gone before. His concise summary of progress ranges from Berzelius (1814) to Charnot (1915); after which is a formal bibliography, including all papers on the subject which the author has been able to catalogue.

After this good beginning, the technics are concise but full. The old "lapidary's bench," as figured on p. 1205, Vol. III., of Holtzapffel's classic "Turning a Mechanical Manipulation," and as still used in many workshops, has no place in the present list of necessaries; but we have a figure of Sauveur's machine for polishing steel, in which four graded surfaces are all available in immediate sequence, a machine which will finish a specimen in an average time of six or seven minutes. The prospector is, however, told how he may operate—more laboriously, it is true—even at a remote mine, and with materials which may be carried in the waistcoat pocket.

Mounting, ocular examination as by the microscope, photographic recording under orthochromatic conditions, colour comparisons, needle-testing and reagent-testing, are all concisely, but by no means superficially, dealt with, after which the work is completed by elaborate tabulations and classifications, all clearly expressed, concise but nevertheless full.

A plate of four photomicrographs, plotted out in colours to indicate species, and with key colours, is not only instructive in itself, but also highly suggestive to the student. Here we have really good photographic rendering of exceptionally difficult subjects. A feature which may be mentioned is the considerable use made of cut-out leaves, after the fashion of an index book, so as to facilitate immediate reference to the various sections.

GENERAL NOTES.

Röntgen Society.—In a paper by Mr. C. R. C. Lyster, M.R.C.S., and Dr. S. Russ, on "A Biological Basis for Protection against X-Rays," the study of the protection of X-ray operators was approached from a somewhat different point of view from that usually adopted. In previous investigations the materials have generally been tested to ascertain what fraction of the incident rays are transmitted, while in this case an attempt was made to measure the total quantity of radiation received by the operator during, say, a day's work under normal conditions. For this purpose the operator carries a photographic plate upon his person, and at the end of the period under consideration the plate is developed. The density of the resulting image is compared with that of another plate termed the "biological basis plate," which has been exposed under standard conditions of radiation. A preliminary investigation enables the harmful effects of the standard source of radiation to be determined, and thus gives a meaning to the indication of the biological basis plate. Radium forms a useful source of radiation for practical purposes after the initial tests have been made, and it overcomes difficulties in the employment of an X-ray tube as a constant source. The effect of hard and soft radiation (twelve-inch spark to two inches) on the photographic plate was fully investigated, and it was concluded that for the same ionising effect the

hard and soft rays produced about the same photographic effect; the effect, however, varies with different makes of plates, and in consequence all comparisons must in practice be made with the same variety.—Mr. E. C. Head gave a detailed description, illustrated by numerous photographs, of a motor X-ray unit recently designed and constructed for use in Mesopotamia, etc. The Austin chassis was chosen on account of its low load-line, and the body was divided into two portions, one to serve as dark room, while the other contained the X-ray equipment. In operation a tent is erected at one side of the car, with the result that it is unnecessary to remove the coil or switchboard for use. Electric current is supplied from a dynamo run off the motor engine and from a small battery of accumulators, and is sufficient to render possible the production of short-exposure radiographs.

MIGRATORY BIRDS AND FOOD SUPPLY.—Mr. Clynes (Parliamentary Secretary, Ministry of Food) stated in the House of Commons on March 7th that the common and statutory law for the preservation of wild birds in Ireland was still in force, except that the Department of Agriculture had power, under the Defence of the Realm Regulations, to take action for the destruction of birds with a view to the protection of crops, and in the case of migratory wild birds for improving the food supply of the country.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

APRIL 10.—W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry." PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., will preside.

APRIL 17.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

APRIL 24.—MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons." The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

MAY 1.—GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

MAY 8.—JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India." The RIGHT HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m.:—

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana." SIR EVERARD IM THURN, K.C.M.G., C.B., will preside.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m.:—

J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day."

Syllabus.

LECTURE I.—APRIL 8.—Explosion and detonation—High and low explosives—Propellant power and disruptive violence—Requirements for military use—Materials and their sources—Ammonium nitrate and other nitrate mixtures and their military applications.

LECTURE II.—APRIL 15.—Other high-explosive mixtures and their uses—Chlorate mixtures—Nitro-cellulose and nitro-glycerine, and mixtures containing them—Military smokeless powders.

LECTURE III.—APRIL 22.—High explosives used for shell filling—Methods of detonation—Initiators of detonation—Tests applied to explosives—Miscellaneous.

SPECIAL LECTURES.

A special course of three lectures on "The Freedom of the Sea" will be delivered on Thursdays, May 2nd, 9th, and 16th, at 4.30 p.m. The first lecture will be given by Mr. GERARD FIENNES, the second by SIR FRANCIS TAYLOR PIGGOTT, LL.M., and the third by Mr. JOHN LEYLAND.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

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CONTENTS.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

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FRIDAY, APRIL 5, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK.

MONDAY, APRIL 8th, at 4.30 p.m. (Cantor Lecture.) J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." (Lecture I.)

WEDNESDAY, APRIL 10th, at 4.30 p.m. (Ordinary Meeting.) W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry." PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

PROCEEDINGS OF THE SOCIETY.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 6th, 1918; The RIGHT HON. FREDERICK HUTH JACKSON, M.A., in the chair.

The following candidates were proposed for election as Fellows of the Society :—

Anstruther, George Elliot, London.
Crabb, Thomas, M.I.Mar.E., A.M.I.Mech.E., Bengal, India.
Hepburn, Andrew, Horley.
Letcher, William Whitburn, London.
Mannell, John, London.
Mitchell, Ernest J., London.
Murray, Alexander Robertson, Calcutta.
Pardoe-Thomas, Bertie, J.P., Newport, Monmouth.
Pocock, George, London.
Poupart, John, Walton-on-Thames.
Powles, George Everett, Leeds.
Rama Varma Raja, His Highness, M.R.A.S., F.R.Hist.S., Malabar, S. India.
Robertson, Walter Henry Antonio, Bedford.
Stewart, John, London.
Tonkin, Wilfrid Wiseman, Lic.R.I.B.A., Potchefstroom, South Africa.
Ullyott, E., Leeds.
Walter, Francis Henry, Rio de Janeiro, Brazil.

The following candidates were balloted for and duly elected Fellows of the Society :—

Brocklebank, Rev. Clement Edmund Royds, London.
Drummond, George Henry, London.
Hobson, Arthur E., Connecticut, U.S.A.
Jou-lin, President Tsao, China.
Leverhulme, Lord, London.
Marshall, Herbert J., Gainsborough.
Metcalf, Henry E., London.
Mortimer, Engineer-Commander John Ernest, M.I.N.A., M.I.Mech.E., London.
Ogden, Henry Joseph, London.
Pantin, Carl Frederick Abel, 2nd Lieut. R.E., London.
Pantin, Herbert, London.
Quin, Lawrence Howard, London.
Rodd, Charles, Poole, Dorset.
Stephens, Mrs., London.
White, Charles, Aberystwyth.

The paper read was—

THE FOUNDATION OF INDUSTRIAL PEACE.

By A. H. PATERSON,
Secretary, National Alliance of Employers and Employed.

National safety now and national prosperity at the end of the war depend upon the preservation of industrial peace and its development upon broad constructive lines.

Everyone feels this, from Ministers of the Crown, great employers, and Labour leaders, whose sentiments are expressed on public platforms, to the toilers in factories and our soldiers on the battlefield, whose sentiments seldom find any public expression at all.

Unfortunately, while we all desire industrial

peace for our country's sake—even the reactionary who would like to see "unrest" suppressed by the machine-gun, or the anarchist whose panacea for all ills, industrial and other, is to turn Society upside down—yet each of us wants most of all a particular kind of peace of his own.

The class-conscious Socialist and disciple of Karl Marx is as anxious as anyone that British trade should compete successfully with foreign rivals after the war, but he holds it to be his first duty, whatever may betide, to strive for the transference of ownership of capital from private hands to those of the workers in each trade who, he maintains, alone should control production.

The State Socialist, and certain functionaries who have taken office lately in Government Departments, are sworn foes of Prussian Bureaucratic tyranny, but they believe that the chief needs of this country during the reconstruction period will be control, and even management, of industry by the State, and the appointment for the purpose of intelligent Government officials on a permanent basis and with plenary powers.

The trade unionist is ready to agree that foreign competition and the international market price of goods will affect wage rates in the future, and that no premium should be put upon inefficiency or slothful labour, but he considers it to be his primary duty to get out of employers on all occasions the highest possible pay obtainable for all members of his union.

The average employer, on the other hand, though agreeing with the principle that workmen should receive a fair share of the proceeds of production, and that all who labour should be paid a living wage, is nevertheless convinced that the direction of business must remain conclusively in his own hands; and though he is in favour of Labour becoming more intelligent and better organised, and even better educated, yet if you press him he will admit that he prefers workmen who leave the thinking to him to those who think for themselves.

The so-called "capitalist," too—that is to say, the man whose income is derived from dividends on invested funds or real estate—though quite alive now to the need of harmony between "Capital and Labour," and especially anxious that there shall be no strikes or lock-outs where he has business interests, demands from the management of his companies as high a dividend as business exigencies permit.

Then the consumer: he, or rather she, is a patient creature nowadays, and is often secretly proud of the sacrifices which the war has forced upon her; but when the war is over and tradesmen compete for her custom, it will be no longer a question of patriotism, but of cheapness. The producers, she will say, have had their day. It is now her turn. And whatever happens prices must go down.

Last of all, and most important, we have to reckon with the point of view of the men in the Army and the men, and the women, in munition works—especially those who do not belong to trade unions, and who will have no "trade" to return to when the war ends.

It is not easy for us at home to realise what soldiers who have been separated for one, two, or three years from industrial life feel exactly in regard to the future of industry, and it is still more difficult to form conclusions as to what they will say and do when they are no longer needed on the battlefield.

But there are certain things we know—those of us who have been in close touch unofficially with the men in France and on home service. We know, for instance, that though official departments propose, sensibly enough, that the Army shall be gradually demobilised, and only those men released at first whom their country wants to fill up industrial gaps, our soldiers, one and all—skilled artisan and casual labourer, cook and costermonger—are possessed of a fixed determination that the moment peace is signed they will all come home at once.

Such a determination is, of course, unreasonable. It is almost immoral in the eyes of official persons who have never known the hunger for home-life which has become almost a madness to hundreds of thousands of our civilian Army, and which, like all madness, may become extremely dangerous unless it is gently and humanely, as well as firmly, dealt with. And that determination, bear in mind, is growing stronger and more widespread as the war drags on.

There is nothing inherently revolutionary in this attitude of our soldiers. The lads are just mortally tired of it all, and though the way in which they talk about high authorities of Government, or even of Parliament, shocks many people, it is only a habit they have. Soldiers do not trouble themselves about class-consciousness, nor do they claim ownership of capital, or even yearn for the sharing out of real estate and the nationalisation of the land; while State control of any kind receives short shrift if mentioned in their hearing. It has held their lives in its grip all these weary years, and they have had

enough of it. They will accept anything the State may give them and take it as their right, but they will never consent to be under its control again.

They just want to get home—that first. Then they want a rest, then to get a job, and after that a peaceful and a quiet life for ever and ever more. But they want all this in a way which, if they are thwarted or disappointed in any reasonable expectations, and begin to feel their country and its rulers have forgotten them, and having exploited some of the best years of their lives, and made them endure misery and hardship unspeakable, and the risk of death itself, are going to "turn them down," as they would say, and leave them to struggle like blind kittens in the whirlpool of industrial competition at the end of the war, they will be far more dangerous to the peace of the realm—not to mention that of industry—than all the anarchists and "down tools" men to be found in these islands at the present time put together.

Of course, no one wishes or intends to turn them down. All of us, no matter what our views may be of a future social and industrial State, are united in a resolve to see justice done to those but for whom our State would have no future at all. We are apt, however, to forget or, at least, very much under-estimate, the sacrifices which will have to be made, and the difficulties which must be overcome, to give our fighting men what they need when their task is done.

This brings me to the point of view of the munition workers.

The Minister of Munitions stated the other day that those he employed numbered from two to three millions. He was well within the mark. Now most of these workers will be demobilised and return to their homes within a few weeks or less of the day peace is declared. What is to be done for them and with them?

They are asking this question with much anxiety. They feel that public opinion, easily aroused for the soldier, will not trouble itself much about their fate. There will not be much sentimental feeling, they know, for civilians, the majority of whom have earned wages many times the amount of a soldier's pittance without having had to risk their lives in the process.

This is true, but there is another side to the question which the soldier who is far from home sees very clearly.

The most urgent need of the country in industry, when the war is over, will be efficient workmen and workwomen to manufacture goods for home and foreign markets. It is the common opinion of everyone engaged in trade and commerce that maximum output, and maximum output alone, of all those articles with which this country can supply other countries, will enable the nation to hold its place in the world's market, and meet its liabilities.

The men in the trenches now cannot at first be as efficient for very many kinds of skilled employment in factory or workshop as those who have been there throughout the war. Hard manual labour and all kinds of unskilled work the average soldier will be well fitted for; but, in a strictly industrial sense, and on a business basis of supply and demand, the better paid jobs when demobilisation comes will be taken up by munition workers, and it must be admitted, that as far as production is concerned, this will be to the advantage of our industrial position.

There is the further point that the munition workers will be on the spot ready for immediate transference to reconstructive work. It is this fact, above all others, which causes the soldier to blaspheme when high officials in this country lay stress upon a plan of gradual demobilisation. If, in addition to being held back too long from their homes and dear ones, the men of the forces find that preference in re-employment is being given to the men and the women who took their places in industry when they—the soldiers—were forced out into military service, there will be trouble of the most serious kind.

It is not within my province to suggest to you to-day practical ways and means for meeting this particular dilemma. Our concern now is to consider whether any sure and stable foundation can be laid down on which may be built up any industrial peace sufficiently comprehensive, effective and permanent to solve the problems and meet the dangers I have endeavoured to indicate.

I believe that such a foundation can be established. I would even go so far as to say that the power of creating all that is needed lies ready to hand. If all forces engaged in industry were to seek alliance with one another for an improvement in those conditions of industry which all alike concur in feeling to be of vital importance, not one of the differences that exist between them, and probably always will exist, would drive them into war.

I shall be told that this is an impracticable proposition. Many people, indeed, have said that it is quite impossible. I would ask all such people whether if, in 1913, those achievements

of this country in the war due solely to employers and employed, and Government officials too, working in closest alliance, had been described as possible, any business man of that day, or employer or leader of Labour would have believed it? Alliance between employers and employed is not only possible, but it is being established. It is a tiny seed at present, its main achievement so far the creation of confidence and mutual trust among representatives of certain employers' associations and trade unions and the members belonging to such bodies. It has, in addition, created an atmosphere of friendliness among local groups of workmen and employers in some large industrial centres. Last, but not least by any means, it has begun to cause serious annoyance to the more extreme and bigoted advocates of industrial division, disruption and dissolution.

All that is needed now is that the people of this country, irrespective of class, politics, and divergent points of view over the relative position of "Capital and Labour," shall realise the importance of peace in industry, now and after the war, as they have realised the need for the struggle with Germany, and shall be ready to make some part—not a great part—of the sacrifice to obtain it which they are making so heroically to beat Prussian militarism to-day.

I know everyone is tired of sacrifice. All are looking forward to a brighter world when we have won through, and to the realisation of those social ideals which have to be held in abeyance while the common enemy remains in the field.

Yet if it is realised that none of the ideals we cherish can possibly be attained unless there is peace between Capital and Labour, the very determination in our hearts to create better things for ourselves, and our class, will be an incentive to laying a foundation for our country of an industrial peace which it shall not be possible for irreconcilables of any kind to break.

I think that throughout the nation to-day a feeling is steadily growing that at whatever cost to private or sectional interests a way must be found to consummate such a peace.

I speak from personal experience. It has been my duty, and I may say great privilege, to address frank and thoroughly informal conferences of employers and of workmen in great manufacturing centres in the North, the Midlands, and South Wales, and to hear expressed the most candid views and opinions upon the causes of industrial disagreement and strife. I have also attended public meetings where men and women of all classes have been addressed by representatives of both sides, standing together on the same platform.

At these conferences and meetings, especially the informal ones, held at such places as Liverpool, Manchester, Birmingham, Newcastle, Sheffield, Cardiff, and Swansea, Worcester, and Gloucester, I have heard the hardest things said and the roughest heckling administered to men like myself who took up the cudgels for peace and goodwill.

But what has struck me most on every occasion has been this: Not one speaker had a word to say against the principle of whole-hearted co-operation between employers and employed to deal with dislocation of industry, and the vital problems of demobilisation and reinstatement of soldiers and munition workers after the war. Where they differed and argued against one another, or against me, was in regard to the means by which effective co-operation should be brought about. Another thing—most significant, perhaps, of all—the cause of any objection to joint action between managers in the counting-house and labourers in the workshop to improve business and raise the condition of the workers, was always suspicion of the motives of the man on the other side which, when traced to its source, proved to be nothing but sheer ignorance of his real attitude and intention.

Again and again, after long, hot arguments, and the use of language quite unprintable, it has been just those men who at first were most opposed to any approach to working hand in hand with men of a different class who became the keenest and most determined apostles of a shoulder-to-shoulder policy of men of all classes, be their social standing what it might, so long as they proved themselves to be men of honest goodwill.

Another lesson I have learned. Industrial peace cannot be founded upon "co-operation" merely. It must rest upon alliance for a common purpose.

Would "co-operation" in our Army hold the Germans back? Only comradeship, tried and true, comradeship on an equal basis—such as men feel when hunting a tiger in the jungle on foot—will found any peace in industry in this country worthy of the name.

This is what we want and must have to win industrial peace. That is why I began by suggesting the necessity for sacrifice. There is no difficulty about sacrifice if there is comradeship, but nothing less potent will inspire it.

Let us now consider how this comradeship, which I hold is the true foundation on which

industrial peace can be built, can be created and begin its work.

I claim no originality in emphasising the need of comradeship among members of the classes and masses; the employer and the workman; the producer, the consumer, and the Government official.

The National Alliance of Employers and Employed, which I have the honour to serve, was actually the first body of men which laid down in public more than a year ago the urgent need of such comradeship as I have described among employers, employed, and the Government, to deal with demobilisation problems. Further, I have not yet seen any conference of Labour or of employers, or both together, or recommendation made on the subject by any Government Committee or Commission since the National Alliance put forward its programme for demobilisation, in December, 1916, which has not taken very large bites out of our programme, sometimes even reproducing the whole of it without, of course, any acknowledgment whatsoever.

But that is a matter of no public importance. It is, from a national standpoint, to the good that the pronouncements of a group of private citizens should have been adopted *en bloc* by the Industrial Unrest Commissioners (after investigations of their own); by the Whitley Committee; and voluntary organisations such as the Industrial League for improvement of relations between employers and employed; and, the latest creation of all, the Industrial Reconstruction Committee.

I am in no way concerned here with the claims of any individual organisation, least of all my own, to recognition. The point at issue is how we are to found the peace we need—not who is to be the instrument.

To decide this question we must go far beneath the surface of things. The greatest danger of all to such a cause as this is the tendency in human nature to like window-dressing and neglect the real substance for the obvious shadow.

We have before us, for instance, the Whitley Report proposals for joint industrial councils of employers and employed in each organised trade. Excellent, sound, and practical proposals they are. I wish them every success. But I cannot myself accept them as a foundation for industrial peace. They are part of the building above.

Masters and men in several large trades have already been in the habit of meeting together on trade questions. Their meetings, however, have not resulted in the comradeship we need for industrial peace, or even in any particular good-will. The reason is not far to seek. When employers and workmen of a trade meet together on trade matters they are simply there as men of business to discuss business problems —the men to get the best they can in their own interests, the employers in theirs. Men may meet one another on a business basis of this kind for years—without becoming even friends. I know that the Whitley Recommendations suggest that subjects outside ordinary trade questions shall be dealt with by these committees, but I fear that an atmosphere of business, not of comradeship, will prevail. Now, industrial peace will never be secured upon a foundation of business relationship between Capital and Labour.

On the other hand, the establishment of joint trade committees is an essential part of any structure of industrial co-operation.

The foundation to this can only be laid by the establishment in each industrial centre or area of a district committee or council for purposes partly industrial and partly social of employers and workmen in equal numbers, representing employers' associations and trade unions of all trades and occupations—each district committee or council so formed to be represented upon a central and national council, which, through an executive committee, consisting like the local bodies of employers and employed of equal numbers, shall co-ordinate and mould into a combined national force all that given in service or authority by the joint local industrial forces.

With these committees or councils, local or central, of employers and workmen, there must be associated men and women of all classes, who may elect representatives on the committee to serve with the employers' and workmen's representatives, and by their associate membership—which should number hundreds of thousands as the objects and motive of the movement became known — give moral and financial support capable of becoming a powerful source of strength and stability to their industrial comrades.

The work of this union of forces both industrial and individual must be confined, as far as possible, to promoting those general objects which are common to employers and workpeople of all trades, and the members of the community at large who cannot be considered to belong to either side.

Among these are satisfactory housing of the industrial population; the proper conditions of lighting, heating, etc., of all workshops and

factories, together with "welfare" work in all its branches; education, especially of a non-technical kind; the status of women in industry and the future for women's work; the main principles on which demobilisation and reinstatement both of munition workers as well as men of the forces, should be carried out; the very vexed and difficult questions of administration of Employment Exchanges, both in connection with demobilisation and in the future as a permanent system; the infinitely important and equally difficult subject of imparting knowledge of the business of a firm or company to those who labour in the works, and giving representatives of such works real power in regard to management, so that a partnership in point of feeling, at least, may be established between each employer and his men—without, of course, weakening trade union organisation on the one hand, or, on the other hand, undermining discipline, and the rightful authority of the directorate of the company.

Most important and, in the face of all that is to come at the end of the war, absolutely vital to industrial peace, will be the securing of safety for both sides in times of bad trade. The workmen I have seen over these matters, place far more stress upon this point than on any of the others. One, a man of extreme views, went so far as to say that if employers and workmen could stand shoulder to shoulder in this matter, nothing more need be done to ensure industrial peace and goodwill.

It is indeed a problem which only comradeship in the closest sense can solve, for it means much mutual sacrifice and give and take. It is one that can never be settled piecemeal by separate trades boards. It is one which, if, taken in hand by Governmental authorities alone, will wreck everything, causing heartburnings, favouritism, pauperisation, and a general demoralisation of all workmen or employers taking any part in it.

It may reasonably be questioned whether a voluntary organisation strong enough to carry out such a program as I have sketched can possibly be set up in the midst of this war. Undoubtedly it will be a difficult task, especially as several powerful interests will not look favourably upon the establishment of a voluntary combination of this kind. But I would venture to reply in Cromwell's well-known words: "Gentlemen, it is of necessity and therefore to be done."

It is of necessity that adequate means shall be devised to bring men of all classes to work together for the general betterment of industrial conditions on a voluntary basis. That and that alone is a sure foundation, I venture to repeat, on which to build up the work of the Whitley Committees, Government Resettlement and Reconstruction Committees, Employment Exchange Boards, Trade Boards, and what not, and to make them effective for the purposes for which they are assigned.

If such a foundation is not laid, and speedily, the disruptive forces now at work, political, social and bureaucratic, are such that, though we shall, I believe, win through our struggle with the Central Powers, yet we shall be beaten utterly afterwards on industrial issues by our own Allies—especially America—by neutrals, and finally by Germany herself.

And it is to be done, for already the ground has been tilled and seed sown in many a city and town, both in England and Scotland. In these places and in London, men—employers, Labour men, and men of business—who up to a few months ago were entire strangers, ignorant and indifferent to one another's thoughts and ideals, are now working day by day in the closest companionship for just this one object—the construction of a foundation for industrial peace

Each day this number grows. Also the number grows of men of every class and from all parts of the country, joining as associate members, from great Companies and Trade Unions which send £100, to workmen who contribute 1s. annually, which entitles an associate member to be entered on the membership roll.

It is yet only a small band in point of numbers, but a very hopeful one—great in faith and courage; and, I believe, in all earnestness, that it represents forces in this country which will in very truth bring peace into our industrial world and be the foundation of true comradeship and brotherhood among the men who lead that world, not only during the reconstruction period but for all time.

DISCUSSION.

THE CHAIRMAN (the Right Hon. Frederick Huth Jackson), in opening the discussion, compared the paper with that read before the Society recently by Lord Leverhulme. Lord Leverhulme gave the conclusions he had arrived at from his experience as a large employer of labour, while the author of the present paper gave the conclusions he had arrived at from close touch with employers and workmen all over the country, and with soldiers home from the front, and the extraordinary resemblance between those conclusions was most remarkable. Lord Leverhulme advocated shorter

hours of labour and higher wages, and had established a system of profit-sharing in his own works, while the author did not particularise but confined himself to advocating the adoption in industrial life of that spirit of comradeship which existed to a striking extent among the soldiers at the front. Both Lord Leverhulme and the author insisted on the absolute necessity of introducing a different atmosphere into industrial relations, the substitution of a spirit of mutual goodwill for the spirit of mutual distrust and suspicion which prevailed in this country in the relations between employers and employed just before the war. He cordially agreed with all that the author had said on that subject, and believed that if this country could secure the whole-hearted co-operation of employers and employed after the war its future greatness would be assured. Some people might say that the members of the National Alliance of Employers and Employed were idealists aiming at the impossible, but his answer was that Lord Leverhulme and many other large employers of labour, as well as leaders of representative and important trade unions, had expressed their approval of the movement initiated by the Alliance, and were supporting it with their influence and with their money. If the war was followed by serious labour troubles, such as those that were threatening just before war broke out, and if this country returned to the conditions which prevailed in the summer of 1914, then its future was indeed a gloomy one, and it was surely worth while for all ordinary citizens who had no direct interest in the relations between capital and labour to do their best to avert such a contingency. The National Alliance of Employers and Employed fully realised the difficulties of its work, but it was composed of a determined and enthusiastic body of men, and if those men could indue the public with some of their determination and enthusiasm the success of their work would be assured. He would like to conclude his remarks by two quotations. The first was a remark made by the late Earl Grey, one of Great Britain's overseas administrators, who said: "I am certain of this: character is poisoned by self-interest. I do not care how good a man is; when it is his interest to cut down wages or to give as little of his skill as he can, that man will infallibly lose his sense of justice. He will deteriorate. Give him another principle, make him feel that he owes a duty to his fellow men, convince him that he is responsible for the welfare of others, and all that is good in that man's nature will grow and respond." The other passage he wished to quote was from the great patriot and statesman, Edmund Burke, who said: "Magnanimity in politics is not seldom the greatest wisdom, and a great Empire and little minds go ill together." If those remarks could be impressed upon the mind of every person in this country, that new atmosphere would be created which was so essential if the serious problems which would confront this country when the war was over were to be successfully solved.

Mr. Basil E. Peto, M.P., said that, although he appreciated the aims and objects of the author and the Alliance of which he was Secretary, to his mind there was a want of definiteness about the Alliance's programme of comradeship which might perhaps prevent it doing all that its promoters intended. He was rather disappointed to hear the author state that co-operation in business relations would not produce comradeship, because he thought that the best possible comradeship in industrial life was produced by the feeling that employers and employed were working together for a common object, and that both would reap some reasonably fair rewards from their common effort. Co-operation in its widest sense, by which the workmen had some share in the results of their industry in addition to their wages, was the most potent force in the establishing of industrial peace. The author had stated that the object of the trade unions was always to obtain the highest possible pay for their members. During the war so-called pay in pounds sterling had doubled, and the State, when it wanted to borrow, paid about twice the rate on interest on capital that it paid, say, twenty years ago, and as everything people wanted to buy now cost twice as much as it did before the war their spending power was very much in the same position as it was then. For very many years the people of this country, encouraged by the Bank Charter Act, had been worshipping the pound sterling: the working-classes were not to blame for that attitude, as they were only following the example of people who were supposed to know more about finance. What was really essential now was to make everyone realise the truth of the author's statement that the maximum output was the one thing to be aimed at. The working-classes must be shown that the man was the real benefactor who enabled them to produce more, that it was only by increased production that increased consumption could be brought about, and that the present vicious circle of increase of wages and increase of cost did not benefit anyone. He noticed that the author referred to consumers as constituting a separate class; but every producer was also a consumer, and he did not believe there were any consumers who in the long run could consume if they did not also produce. The conditions necessary for industrial peace and increased production were, first, improved processes of manufacture; secondly, that labour must have a direct interest in the results of their individual effort; thirdly, that there must be absolute security for the possessions of each individual, apart from absolutely necessary taxation; fourthly, that there must be opportunities for individual advancement, both commercial and educational. It was also of great importance that the finance of the country should be so arranged that a far better system of credit could be established and productive enterprise made, as in Germany, a matter of the first importance.

Mr. Harry Dubery (Secretary, Post Office Federation) did not agree with the statement that trade union leaders taught their members that the chief object of trade unionism was to secure increased wages. The ordinary trade union worker had met with certain obvious experiences which taught him certain doctrines. With regard to the question of maximum output, for instance, unless that maximum output was combined with high and increasing wages, and with absolute security of tenure, no trade unionist would approve of it, because if maximum output was combined with low wages it meant that a large stock of goods was produced which in time created a surplus, which, owing to their low wages, the working-classes could not buy, and they were automatically thrown out of work because the maximum output had produced an over-stocked market. The working-man, therefore, came to the conclusion that if he worked too hard and produced a great deal he would be thrown out of work more quickly than would otherwise be the case. Those facts were not taught by trade union leaders, but were acquired by the men through their actual experience. If conditions could be created whereby a man had security of tenure, and knew that if he worked hard he would not be thrown out of work, and also knew that some of the excess of commodities created would come back to him, a different atmosphere would be produced, and he would agree to the doctrine of maximum output being necessary. The author suggested that Trade Boards would not necessarily produce the atmosphere he wanted. That was true, but such Boards were a very excellent preliminary. Amongst the group of trade unions which he represented, increased wages were formerly obtained by great public meetings, press campaigns, lobbying in the House of Commons, talking about strikes and producing an atmosphere of unrest—all of which made for the opposite of maximum output. Now, however, Boards had been set up—on one of which he was sitting at the present time—which consisted of an independent chairman, three representatives of the employers, and three representatives of the trade unions, and which discussed the necessary wage increases that might be required. The creation of those Boards had prevented in the last two years at least three periods of agitation and unrest in the Government Service. Immediately after the termination of the war the Government proposed to build another large Post Office which they intended to be the best planned and best equipped Post Office in the world, and they had formed a committee to consider its design and scheme of working, for which the trade unions had been asked to nominate representatives. By working together in that way the basis of industrial peace was secured. On all Wage Boards and other committees of that kind both sides must sink their personal desires and put first the social betterment of the country, and in that way the right atmosphere would be created for the establishment of industrial peace.

Mr. E. W. Mundy (Secretary, Labour Co-partnership Association) agreed with Mr. Peto that the idea of comradeship put forward by the author was rather intangible, and he would have liked him to be a little more definite as to how industrial peace could be brought about. The Association he represented had for more than twenty years preached much the same doctrine as that which the author now put forward, but instead of calling it "comradeship" they called it "co-partnership." They had adopted the word "co-partnership" as meaning a partnership between the employer, representing capital, and the employed, and had started out on a rather material basis, namely, profit-sharing, in order to get one common interest between the employer and the employee on which they hoped to build higher and nobler interests between the two parties. Under the co-partnership scheme the worker was given his share of the profits in capital, so that each worker became a capital-holder or a partner in the business in which he was engaged, and he was also given a share of control. The author said that when the two parties could be induced to sit round a table and discuss their difficulties, in nine cases out of ten a solution could be found, and that was what the co-partnership movement had been advocating for many years. In the South Metropolitan Gas Company such a committee had been sitting for a long while, and there were similar committees in various works all over the country, and he hoped more would be formed through the agency of the Whitley Report. He thought the committees advocated by that report would be far stronger if the individual workers upon them were also shareholders and had a pecuniary interest in the business. He would like to ask the author whether the National Alliance of Employers and Employed had made any attempt to work out a real science of wages. There was no such science in existence at the present time to his knowledge—only the old idea of the law of supply and demand.

Mr. Robert True did not think profit-sharing could apply to an industry as a whole. He knew of a committee which had been in existence for the last seven or eight months in connection with a certain business, and which was composed of representatives from various departments of the works, whose duty it was to consider improvements, complaints or grievances, and bring them before the management, thus giving the men in the shops a share in control. He could not think that the average working-man desired or had a right to a seat on the board of directors, as some people suggested. The workmen wanted comfortable working conditions and to know that if they brought forward suggestions they would receive consideration. In the case of the committee he had mentioned, the remuneration for the improve-

ments suggested was based upon the actual saving they brought about, and the suggestions, which were brought forward monthly, were increasing in number and in value. Profit-sharing was, he thought, only applicable to individual businesses that could look forward with certainty to making profits, for in a business where profits were uncertain it was very difficult to convince the men that they had not been made. He had a great deal of sympathy with the author's proposals, and believed they were going to be successful.

Mr. E. O. Greening said he had had the pleasure of working with Mr. Hughes, the Rev. Charles Kingsley and others in founding a number of industrial co-partnerships in connection with the co-operative movement. The first report of those was compiled in 1883 and the most recent in 1916. There were now seventy societies scattered all over the Kingdom in all kinds of trades and industries, in which the workers, the capitalists and the consumers had joined hands, and in which the profits were divided between them and control was shared among all parties. In all those workshops there had been industrial peace, with no strikes and no lock-outs. In 1883 their output for each £100 of capital only amounted to £160, but in 1916 they had increased to £230. The growth had been a steady one, increasing year by year. The profit on the capital employed had also increased from 8·62 per cent. in 1883 to 17·10 per cent. in 1916. Therefore the industrial peace which had prevailed in those workshops, together with the increased zeal, economy and industry which were brought into the work, had added 50 per cent. to the output and doubled the amount of profit between 1883 and 1916. Would the author say that the workers who could produce that remarkable result were to be content with merely a sentiment of comradeship being established between them and the employers? Supposing that men working eight hours a day were instead to work nine hours and receive no extra wages, if at the end of the year there was a surplus the employer would probably say that the men were to be paid for the extra time they had put in, and the results which had come from that extra time. Was it not the same thing if the men, without increasing the number of hours, put nine hours' work into eight hours, and should they not share in the results? There ought to be some definite, equitable arrangement by which the worker should receive a share of the profits produced by his extra exertion.

Mr. Paterson, in replying to the discussion, said that "co-partnership" was in one sense a stronger word than "comradeship," but its commonly accepted meaning had made it something which was not strong enough for what was really necessary as a foundation. He was only speaking of the foundation and not of the building. If Whitley Committees, Trade Boards, and the Committees such as Mr. Dubery had mentioned were not going to be built on his foundation, then that foundation was of no use at all, but the type of committee recommended in the Whitley Report only dealt with organised workers, who constituted only about 4,000,000 out of the total workers of 18,000,000, and therefore was not capable of actually being a foundation. The criticism had been made that the proposals put forward in his paper were rather intangible, but again he must say that he was only dealing with the foundation—which was that employers and workmen in equal numbers and representative of all trades should meet together, district by district, to discuss certain matters which affected all the men, such as housing. Those conferences would form a foundation of comradeship, and they themselves should work out a science of wages when they had agreed on the foundational subjects such as those particular matters which required attention in their own neighbourhood. In one district in the Midlands where a committee had been definitely formed, it started by taking up workshop conditions, because in that neighbourhood workshop conditions were very bad. The committee was going to visit every workshop in the district, and make employers whose workshop conditions were defective understand that unless those conditions were improved they would not only have labour against them but also the leading employers in the neighbourhood. He thought the impression made by that process upon every employer and workman within that district would enable the Whitley Committees and Trade Boards there to do infinitely finer work, and would enable the co-partnership principle, of which he was entirely in favour, to be set in operation more easily. The scheme outlined in the paper was purely a foundation on which to build.

On the motion of the Chairman, a vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

CHINESE WOOD-OIL INDUSTRY.

One of the most important of Chinese products —and one for which Hankow acts as chief exporting centre—is t'ung-yu, or wood-oil, and the following interesting details of the industry are from a report by the United States Vice-Consul at Hankow.

Wood-oil is obtained from two varieties of *Aleurites*, a small genus of the *spurge* family. Each variety has rather sharply defined boundaries—the mu-yu shu, or wood-oil, tree being found for the most part in the southern provinces, while the t'ung-yu shu, literally tung-oil tree, is confined mainly to Central and Western China. By chemical analysis the oils of these two trees are found to be practically the same, but the t'ung-yu shu is of far more importance

because of its greater hardihood and wider distribution. Fully nine-tenths of the so-called wood-oil exported from China is made from this variety.

The mu-yu is generally found in the Province of Kwangsi, near the city of Wuchow, which also acts as its chief market. Some of the oil is shipped to Hong-Kong, but the trade is not large.

The Yangtze Valley, especially in its upper reaches, is the territory in which the t'ung-yu tree flourishes most freely. The hilly country found in the gorge region, and, in fact, all the land from Ichang westward to Chungking, is particularly adapted for its growth. The plant is most often found on rocky hillsides, thriving on the poorest of soil so long as the annual rainfall is not less than 29 in. and the altitude not greater than 25,000 ft. The tree seldom exceeds 25 ft. in height, is rather ornamental, and has a great profusion of blooms in April. The fruit is about the size of a small orange, and contains three to five seeds not unlike shelled Brazil nuts in shape, although resembling more nearly the hickory nut in size.

The nuts are always gathered before maturity. As they are covered with a husk they are either parched in iron pans or sieves over a fire, or else covered with straw or grass, under which fermentation takes place in the thin fleshy part of the fruit, thus allowing the nuts to be easily removed.

The methods employed for extracting the oil, although crude, are effective. After the seeds are removed from the husks they are placed in a circular stone trough, where they are crushed by a stone roller drawn by a buffalo, cow, or ass. The pulverised meal is partially roasted in shallow pans, then steamed over boiling water, the product meantime being placed in wooden vats fitted with wicker bottoms. The nuts are next placed in steel frames with straw as an outside container. The frames are arranged on edge in a press and pressure is applied. This is usually accomplished by means of a system of wedges which are driven in one after another by means of a huge battering-ram until the brown, watery, and odoriferous oil is crushed out into the vat below. As a rule the oil is then slightly heated and strained through a coarse grass cloth. (If the heating process is carried too far the oil becomes dark brown instead of retaining its desired light yellow colour.) The product is then placed in wicker baskets lined with varnished paper, and is ready for shipment. As a rule, the oil yield is about 40 per cent. of the original weight of the kernels. The refuse matter, which is in the form of cakes, is used as a fertiliser.

In the vicinity of Hankow the native dealers allow the oil again to precipitate, drawing off the clear liquid and selling it to the foreign exporting firms. The residue is then sold to small dealers in Wuchang and Hanyang, who once more skim the oil after a further precipitation process. The oil is then sold to the native boatmen for use on their craft.

About the only variation in the above method of oil extraction is that in cold weather, when the oil congeals to a grease stage, it is necessary to heat the mass slightly in order to allow precipitation to take place. This is usually accomplished by steam coils being placed within the containing tank. Under this treatment the product soon liquefies, the foreign matter drops to the bottom, and the clear liquid is drained off through stopcocks placed just high enough to avoid the thick, muddy sediment at the bottom.

T'ung-yu is widely used throughout China as a paint oil for outside purposes. It is reported that as a drying oil it excels even linseed oil. One of its greatest local markets is found among the native boatmen, who never paint their boats but coat them with the cruder grades of wood-oil, which not only gives the woodwork a bright, lustrous finish, but also acts as an excellent preservative. When certain mineral substances known as t'utzu and t'o-shen are added to the wood-oil and the resulting mass is heated for about two hours, a varnish called kuang-yu is produced, which is valuable as a waterproofing substance when placed on silks, pongees, and similar articles.

T'ung-yu is also used as an adulterant in the manufacture of lacquer varnish, as an illuminant, and as an ingredient in concrete, and when mixed with lime and bamboo shavings it is used by the natives in caulking their boats. The so-called Chinese or Indian ink is made from the soot resulting from the burning of the oil or the fruit husks. The product is also used as a dressing for leather, in the manufacture of soap, and as a varnish for fine furniture. It is chiefly used in foreign countries for the manufacture of varnish from cheap gums. Other oils require a higher and more expensive quality of gum in order that the resulting varnish be of equal grade. This feature, together with the rapidity with which wood-oil varnish dries, has caused the demand for the product steadily to increase.

The growing importance of wood-oil has led countries other than China to look into the possibilities for the culture of the tree within their own domains. The United States in particular has made rather extensive investigations along these lines, and it is reported that soil and climatic conditions in some of the southern States are such as to permit of the tree's growth and cultivation. Certain it is that the product is of sufficient importance to warrant consumers in carefully investigating its future possibilities.

The quality of the 1916 output of wood-oil was below average. This condition was due in large measure to the fact that adulteration to a greater or less extent was practised by the native producers during the entire year. Especially was this so during the period of high market values.

As a rule, tallow seed and peanut oils are the adulterants used, although sesame, rape, and poppy-seed oils are also utilised when their market values are not prohibitive.

The fruit of the t'ung-yu shu, from which wood-oil is made, usually matures about the middle of October, but last year rains prevented the gathering of the crop until nearly a month later.

Practically the entire output of wood-oil is produced in the provinces of Szechwan, Kweichow, Hunan, and Northern Hupeh, their percentages of output in the order named being 35, 25, 25, and 15. Hankow is the chief exporting centre, shipping, in 1915, 34,246 tons of oil, valued at 5,748,490 taels (about £730,000), or over 90 per cent. of the export for the whole of China. Wuchow is the only other exporting centre of any importance, but it in no way rivals Hankow, as its total shipment during 1915 was but 1,880 tons, valued at 315,767 taels (about £40,000). The following table shows China's shipments of wood-oil to foreign countries during the years 1912–15 :—

Exported to	1912.	1913.	1914.	1915.
	Tons.	Tons.	Tons.	Tons.
United States (including Hawaii)	18,328	18,526	15,832	12,852
European countries	13,018	7,311	8,036	3,040
Other foreign countries	3,343	1,761	2,296	2,580
Totals	34,689	27,598	26,164	18,472

China's output of wood-oil has decreased over 45 per cent. during the four years 1912–15, whereas the demand, especially in the United States, has been steadily growing. It is believed, by those most closely in touch with market conditions, that upon the resumption of normal conditions in China and in Europe the trade in this product will reach unprecedented levels.

JAPAN'S INDUSTRIAL DEVELOPMENT.

One of the most noteworthy features in the commercial history of the last three years, says a correspondent in the Commercial Supplement of the *Times*, has been the rise of Japan as an industrial nation. The first effect of the war on trade was to oust Germany and Austria from the world's markets; then the conquest of Belgium put that country out of the running; and, later on, as the struggle made greater and ever greater demands on the industrial resources of the Allies, France, and even the United Kingdom, found themselves unable to satisfy the demands of the overseas markets for all classes of goods. The result has been that those nations which have been able to turn their full attention to industrial pursuits have increased their foreign trade by leaps and bounds, and one of the outstanding examples of this is Japan.

In 1913 Japan's exports were valued at £64,264,000; by 1915 this figure had increased to £71,453,000; and in 1916 to £114,000,000, an increase in three years of 77 per cent. Moreover, the improvement is still going on, for in the first six months of last year the exports were valued at £71,373,000. Presuming that during the remainder of the year trade continued at the same rate—and with America definitely engaged in the war Japan may reap a still greater harvest—the figure for 1917 will be something like £140,000,000, or more than double that of the last pre-war year.

Of course, a certain proportion of this enormous increase is accounted for by inflated prices, but higher prices do not account for the whole of the increase, as will be seen later. The fact is that Japan has recognised her opportunity for industrial and commercial expansion, and has seized it. The Japanese are a clever, energetic, resourceful people, with a special genius for learning from the example of other nations. With an abundance of cheap labour and cheap power derived from the many waterfalls of the country, and helped by the absence of low-priced German goods from the market, Japanese manufacturers have been able to turn out in certain lines goods which, at the price at which they are sold, will probably be able to compete with any the world can produce.

That the Japanese manufacturers believe in themselves is shown by a recent announcement in the native press that the Tokio Gas and Electrical Company, which, besides its ordinary manufactures, is already engaged in the manufacture of incandescent mantles, galvanised iron and enamelled ware, is now increasing its capital from one to three million yen (£102,000 to £306,000). The new capital is to be employed in the manufacture of motor-cars, industrial tools and firearms.

Nor is the manufacturer left entirely to his own unaided efforts. The Japanese Government is fully alive to the advantages of being independent of foreign supplies, and is assisting in a variety of ways in encouraging the establishment of new industries in the country. For example, to render Japan independent of German dyes and chemicals the Government is giving direct subsidies to factories making dyes and certain other chemical products. To encourage interest in the iron industry it has been decided to grant immunity from taxation of all descriptions for a period of ten years to persons undertaking the erection of iron foundries, and also to permit the importation

of the necessary ores and plant duty free. Other industries are assisted by granting drawbacks, when the products are exported, on some of the imported raw materials used in their manufacture, whilst by a system of shipping subsidies export trade in general is helped by ensuring that goods can be shipped to various markets at reasonable rates.

USE OF MOLYBDENUM IN ALLOY STEELS.

An investigation to ascertain why molybdenum as a possible source of economic wealth in the United States should remain undeveloped has been made by the United States Bureau of Mines, and a report on the facts obtained has been published. A preliminary review of the situation showed that the market for molybdenum in alloy steels must be developed or that new uses for the metal must be created before the demand would be sufficient to warrant any extensive mining of the ore.

One of the chief factors in retarding the development of any demand for molybdenum by the alloy-steel trade was that manufacturers who might use, or might investigate the possibilities of using, the metal were kept out of the market by the fear of not being able to obtain steady supplies. On the other hand, those who might be interested in the development of some of the extensive low-grade molybdenite or wulfenite deposits in the United States were prevented from doing so by the small visible demand and the fear that any large production would glut the market. Owing to these conditions, the mining of molybdenum has in the past been confined almost entirely to small-scale operations on high-grade streaks of molybdenite ore, and the methods of recovery have been limited largely to cobbing and hand-picking.

The problem before the Bureau of Mines was to ascertain the character and extent of the deposits of molybdenum ores in the United States from which supplies requisite for the development of the market might be obtained, and how the ores might best be concentrated into a marketable product. The direct purpose of the Bureau is, on the one hand, to prove to possible consumers of molybdenum that the element is not as rare as commonly supposed, and that the United States possesses many deposits of low-grade ore from which large supplies may be derived; and, on the other hand, to prove to present and prospective producers of molybdenum that there is a latent market for their product in the alloy-steel trade which needs only the assurance of steady supplies for a considerable development.

The new publication is Bulletin III., "Molybdenum, its Ores and their Concentration, with a Discussion of Markets, Prices and Uses." Copies may be obtained at 1*s.* 3*d.* each (exclusive of postage) by applying to the Superintendent of Documents, Government Printing Office, Washington, D.C.

A NEW ARGENTINE DYE MATERIAL.

According to a report by the United States Consul-General at Buenos Aires, a joint-stock company has been formed in Argentina for the exploitation of a new dye material "algarrobin," obtained from the wood of the carob tree (*Ceratonia siliqua*), and a factory has been established in the city of Santa Fé, Province of Santa Fé. The material is now in regular industrial use and is said to be giving good results, in addition to proving itself economical in comparison with other dye materials. One local concern, the Sociedad Italo-Americano, is said to be using 3,307 to 4,409 lb. of "algarrobin" monthly, chiefly in dyeing khaki cloth for Argentine military uniforms. It is also said that 66,139 lb. of the product have been shipped to Italy and France, and that additional requests are being received in consequence of the satisfactory and economical results given by the dye. The manufacturers claim that, although cotton takes the "algarrobin" successfully, exceptionally good results are obtained in the treatment of silk and wool.

"Algarrobin" possesses valuable dyeing properties. The fastness of the dye to fulling, light, washing, etc., is notable, as is also the uniformity of tone. These qualities, added to its moderate cost, will render it of value to dyers. "Algarrobin," alone, imparts a light-brown colour to any textile fibre—cotton, wool, silk, etc. These colours are fixed by appropriate mordants according to the shades desired. There is a great variety of methods of employing the dyestuff, and it will be easy for a dyer, with a little practice, to obtain all the tints he requires. In combination with vegetable extracts, such as fustic, hypernic, logwood, etc., it gives a number of varied and fast colours. It is very suitable as a base for dyeing with coal-tar colours, and by its use an economy of 50 to 90 per cent. of the artificial colours employed can be attained.

For the loading of silk and wool it is superior to all materials now currently used, both in regard to increase in weight and to the mechanical properties of the dyed wares.

GENERAL NOTES.

Anopheline Mosquitoes.—In connection with possible risks of malaria being acquired in this country, the Local Government Board are anxious to collect as much information as possible regarding the prevalence and distribution of anopheline mosquitoes in various parts of the country. Naturalists and field entomologists could give much valuable help in the matter by keeping notes and records of any adult insects which they may meet with during natural history searches, etc., and also of the detection of anopheline larvæ,

In making records the following are important: *Adults.*—Date; hour of collection; place (if in a building specify its nature); condition of weather and temperature; whether few or abundant. *Larvæ.*—Date; hour of collection; locality; nature of collection of water (natural or artificial); nature of breeding-place (shady pools, open collections of water, presence or absence of weed, fish, etc.).

ADULTERATED TEA.—In order to ensure that only genuine tea shall pass into the country, all consignments are examined at the ports of entry by inspectors approved by the Lords of the Treasury. Doubtful samples requiring a more complete examination are sent to the Government laboratory. The number of such samples dealt with in the year ended March 31st, 1917, was 13,296, of which 1,172, representing 65,511 lb., were condemned as containing sand or other foreign matter. In addition, 488 samples, or 34,666 lb., were reported as "unfit for human consumption." There was, however, the Government chemist points out, no evidence of intentional adulteration, and it is to be noted that the quantity rejected, though large, is quite insignificant in relation to the total amount of tea imported, namely, approximately 369,000,000 lb., including tea for the manufacture of caffeine. Rejected tea is allowed delivery duty-free for use in the manufacture of caffeine or theine, the alkaloid which imparts to coffee and tea their stimulating properties, and which is extracted for use as a drug.

COFFEE IN BRITISH GUIANA.—According to the *Journal of the Board of Agriculture, British Guiana*, the coffee industry of the colony continues to increase. In 1905 the area under cultivation was 1,432 acres; in 1910, 2,546 acres; and in 1915, 4,468 acres. The Liberian variety is chiefly planted, as it gives good returns, and costs less to cultivate than the Arabian variety. Most of the coffee produced in the colony is consumed locally, only a small proportion being exported.

WOODLAND INDUSTRIES.—The Forestry Sub-committee of the Reconstruction Committee, in their recent report, state that the wood distillation industry had failed to develop in Great Britain before the war, not because the raw material was not available or too expensive, but because of unscientific methods and lack of encouragement from the Government, which preferred to rely on Germany, Austria, and the United States. As illustrating their contention that no woody material should go to waste in a highly industrial country like this, the sub-committee refer to what has been accomplished by the utilisation of the produce of some 2,000 acres of coppice in the Crown woods at Tintern. Attention is also called, in the report, to other small industries, including tent-peg and spoke making, that have been set on foot during the war. The sub-committee add that, with the expenditure of a small amount of capital on better machinery, various other products—wood-wool, for example—might be turned out. Industries similar in character to those mentioned have been developed in other parts of the country. Home-grown beech and birch are quite extensively used in Scotland and in Lancashire for the manufacture of bobbins, thus reducing, to some extent, the import of birch bobbin squares from Northern Europe, while in the South of England hurdles are also made from underwood. Further examples of the uses to which coppice material may be put are clogs, chestnut-fencing, piano-keys, crate-making, ship-fenders, and pencils.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

APRIL 10.—W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association, "Examples of Applied Science in the Cotton Industry." PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., will preside.

APRIL 17.—FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." SIR JOHN SNELL, M.Inst.C.E., will preside.

APRIL 24.—MAJOR SIR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons." The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

MAY 1.—GEORGE MARTINEAU, C.B., "Sugar from several Points of View."

MAY 8.—JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

INDIAN SECTION.

Thursday afternoons, at 4.30 p.m.:—

APRIL 18.—ALFRED DICKINSON, M.Inst.C.E., "Water Power in India." The RIGHT HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m. :—

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912-17, "British Guiana." SIR EVERARD IM THURN, K.C.M.G., C.B., will preside.

CANTOR LECTURES.

Monday afternoons, at 4.30 p.m. :—

J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day."

Syllabus.

LECTURE I.—APRIL 8.—Explosion and detonation—High and low explosives—Propellant power and disruptive violence—Requirements for military use—Materials and their sources—Ammonium nitrate and other nitrate mixtures and their military applications.

LECTURE II.—APRIL 15.—Other high-explosive mixtures and their uses — Chlorate mixtures — Nitro-cellulose and nitro-glycerine, and mixtures containing them—Military smokeless powders.

LECTURE III.—APRIL 22.—High explosives used for shell filling—Methods of detonation—Initiators of detonation — Tests applied to explosives — Miscellaneous.

SPECIAL LECTURES.

A special course of three lectures on "The Freedom of the Sea" will be delivered on Thursdays, May 2nd, 9th, and 16th, at 4.30 p.m. The first lecture will be given by Mr. GERARD FIENNES, the second by SIR FRANCIS TAYLOR PIGGOTT, LL.M., and the third by Mr. JOHN LEYLAND.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 8 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. J. Young, "Military Explosives of To-day." (Lecture I.)

Farmers' Club, 2, Whitehall-court, S.W., 4 p.m. Mr. T. B. Ponsonby, "The Standardisation of Agricultural Labour."

Brewing, Institute of (London Section), Imperial Hotel, Russell-square, W.C., 6 p.m. Mr. E. Earle, "The Application of National War Bond Schemes to Brewery Customers."

Surveyors' Institution, 12, Great George-street, S.W., 5 p.m.

Geographical Society, Burlington-gardens, W., 8.30 p.m. Captain J. S. Barnes, "The Future of the Albanian State."

East India Association, 3, Victoria-street, S.W., 3.30 p.m. Mr. K. M. Panikkar, "Problems of National Education in India."

TUESDAY, APRIL 9 ... Sociological Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. D. Burns, "Democracy and Exceptional Ability."

Electrical Engineers, Institution of (Scottish Section), 207, Bath-street, Glasgow, 7.30 p.m. Mr. E. B. Wedmore, "The Control of Large Amounts of Power."

Asiatic Society, 22, Albemarle-street, W., 4 p.m. Dr. S. Langdon, "The Babylonian Conception of the Logos."

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. Joly, "Scientific Signalling and Safety at Sea." (Lecture I.)

Alpine Club, Savile-row, W., 8.30 p.m.

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Mr. E. Sandeman, "The Derwent Valley Waterworks."

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Dr. G. A. Boulenger, "Exhibition of a head of the Charasinid Fish, *Hydrocyon goliath*." 2. Miss J. B. Procter, "On the Variation of the Pit-Viper, *Lachesis atrox*."

Röntgen Society, Burlington House, W., 8 p.m. Professor Sir Ernest Rutherford, "Silvanus Thompson Memorial Lecture."

WEDNESDAY, APRIL 10 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. W. L. Balls, "The Application of Research to the Cotton Industry."

Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 7.30 p.m. Captain H. Philpot, "Some Experiments with Notched Bars."

Colonial Institute, Caxton Hall, Westminster, S.W., 8.30 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. Joly, "Scientific Signalling and Safety at Sea." (Lecture II.)

THURSDAY, APRIL 11 ... Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Lieut.-Colonel C. S. Myers, "Experimental Psychology." (Lecture I.)

Electrical Engineers, Institution of, and Electrical Section of the Royal Society of Medicine. Joint meeting at the Cancer Hospital, Fulham-road, S.W., 7.30 p.m. 1. Dr. E. P. Cumberbatch, "Diathermy: the use of Electricity for heating the tissues of the body in disease." 2. Dr. R. Knox, "Single Flash (Instantaneous) Radiography, its possibilities and limitations." 3. Exhibition of electro-medical apparatus.

Historical Society, 22, Russell-square, W.C., 5 p.m. Miss V. Methley, "The Ceylon Expedition of 1803."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. A. H. Scott, "Concrete Ships."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. Presidential Address by Mr. H. F. Marriott.

FRIDAY, APRIL 12 ... Royal Institution Albemarle-street, W., 5.30 p.m. Professor E. C. C. Baly, "Absorption and Phosphorescence."

Astronomical Society, Burlington House, 5 p.m.

SATURDAY, APRIL 13 ... Royal Institution, Albemarle-street, W., 3 p.m. Professor E. H. Barton, "Musical Instruments Scientifically Considered." (Lecture I.)

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, APRIL 12, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 15th, at 4.30 p.m. (Cantor Lecture.) J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." (Lecture II.)

WEDNESDAY, APRIL 17th, at 4.30 p.m. (Ordinary Meeting.) FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." DR. J. A. VOELCKER will preside.

THURSDAY, APRIL 18th, at 4.30 p.m. (Indian Section.) ALFRED DICKINSON, M.Inst.C.E., "Water Power in India." The RIGHT HON. LORD LAMINGTON, G.C.M.G., C.C.I.E., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, April 8th; MAJOR-GENERAL SIR DESMOND D. T. O'CALLAGHAN, R.A., K.C.V.O., in the chair. Mr. J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, delivered the first lecture of his course on "Military Explosives of To-day."

The lectures will be published in the *Journal* during the summer recess.

SIXTEENTH ORDINARY MEETING.

Wednesday afternoon, April 10th; PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., in the chair. A paper on "Some Instances of Applied Science in the Cotton Trade" was read by Mr. W. LAWRENCE BALLS, Sc.D., Manager of Cotton Investigations for the Fine Cotton Spinners' and Doublers' Association.

The paper and discussion will be published in the *Journal* of May 3rd.

PROCEEDINGS OF THE SOCIETY.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 13th, 1918; HIS GRACE THE ARCHBISHOP OF CANTERBURY in the chair

The following candidates were proposed for election as Fellows of the Society:—

Aiyar, K. V. Venkataramana, Madras, India.
Besant, A. Digby, London.
Boyd, John T. M., New Zealand.
Butson, Cecil W., Hankow, China.
Hosain, Dr. S. A., Mambuw, Federated Malay States.
Jackson, Right Hon. Frederick Huth, M.A., London.
Meling, Einar, Norway.
Muntz, Sir Gerard Albert, Bt., Stratford-on-Avon.
Narasimham, G., Madras, India.
Preston, Arthur Phillips, Teddington.
Rae, William, M.Inst.M., Kinlochleven, Argyllshire.
Simkins, Alfred George, London.
Spencer, Samuel, Assoc.Inst.C.E., London.
Stephens, Albert John, Gloucester.
Webb, Herbert Charles, London.
Wilson, Edmund Richardson, L.R.I.B.A., New Zealand.

The following candidates were balloted for and duly elected Fellows of the Society:—

Alley, Stephen Evans, J.P., M.I.Mech.E., Shrewsbury.
Briggs, Francis Henry, Knighton.
Chatfield, William Charles, New Zealand.
Davey, Hon. Arthur, J.P., Godalming.
Hart, Sidney George, London.
Leetham, Sidney, York.
McArthur, Thomas, Liverpool.
Reid-Hyde, Major James, London.
Rogers, Henry, Birmingham.
Smith, Alfred, Keighley.
Stewart, Murray, London.
Turner, Sir Montagu Cornish, Romford.
Woodthorpe, John Brinkler, F.C.A., Vancouver, British Columbia.

The Chairman, in introducing the author of the paper, said he desired to be the spokesman for everyone present, and for many who were not present, in welcoming one who had come to describe, from first-hand knowledge, and with authority beyond dispute, the past and the present of a city which had long had an interest—industrial, artistic, and religious—in the life of Europe, and which had now for all English people a very deep modern interest, and for some of them an interest of a very sacred character indeed. The author was going to describe one of the supreme tragedies of the world war, the destruction of what had been beautiful in itself and of great historical interest—a destruction of a kind to which the world had hardly seen a parallel. It was well to collect one's thoughts on an occasion such as the present and put the facts of the war before one's mind in their true setting, as a reminder that the Allies were fighting for the elementary principles of civilisation. Such a meeting as the present one should stimulate the deep sympathy, the active interest, and the warm support of everyone present for all that concerned the welfare of the gallant country of which Ypres was one of the great ornaments. He thought there might be others in the room besides himself who felt somewhat ashamed of the fact that, although journeying often on the Continent, they had failed during past years to become acquainted with a town of such beauty and so many interests, historical and others, and an architecture of a kind which outside Italy had been rare in its combination of municipal, civic, and other glories. Personally he had never seen Ypres in its glory. It was his privilege to spend a day there less than two years ago, but it was not in its glory then; he only saw the shattered ruins of a place which retained then—to a greater extent than at the present time, he feared—at least some traces of what its glories had been. He saw it under conditions of extraordinary difficulty, amid the shriek of shells and the groan of aeroplanes, clad in the unwonted garb of gas mask and helmet, and under circumstances which made quiet thought about what it all meant very difficult. That quiet thought had since had time to mature into the deepest and keenest interest and the greatest anxiety to know all that was to be known about a place which, both in its past and in its present, had so large a claim upon the interest of everyone in this country. It was no small privilege to listen to a paper by a man who was perhaps better entitled than anyone to speak about what Ypres formerly was and what it was to-day, to compare the one with the other, and to put forward also, it was to be hoped, some suggestion of what it might yet revive to become in the future.

The paper read was—

YPRES AND OTHER FLEMISH CITIES BEFORE AND SINCE THE WAR.

By Paul Lambotte,
Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique.

The systematic destruction of the monuments at Ypres by the German army can by no means be justified by any strategic necessity. It is another proof of that Germanic state of mind which makes war, not only against men, but against ideas.

The first startling manifestation of this barbarian mind was the destruction and sack of Louvain. The second was the bombardment of the Cathedral of Rheims. In the determined ferocity displayed towards the Belfry and Cloth Hall of Ypres, we can scarcely doubt that we have a third.

Louvain is the centre of culture and diffusion of catholic science. The University of Louvain, the *Alma Mater*, is essentially the spiritual citadel of science in harmony with faith. It is against her that this crime, coldly premeditated and carried out, was intended. The burning and pillage of the celebrated library, and the devastation of the Cathedral, proclaim this clearly.

The persecutions and fusillades of which so many prelates, monks and priests were the victims in Belgium, and the bombardment of the Cathedral of Malines, were caused by the same spirit, by the same sectarian hate of the Lutheran Emperor who, like a spoilt child, thinks he can annihilate a tradition or a doctrine by throwing down the edifice which it has inspired.

Rheims is, in a way, the Palladium of France's history, creed and tradition. Germany wished to abolish it. It is the glorious symbol of a wonderful national history, which the invading army struck at and tried to destroy. The attempt made on the cottage and chapel of Joan of Arc at Domrémy was inspired by the same mania.

Ypres, on the other hand, is the striking symbol of the persistence of the spirit of the old communers, of the survival of that local particularism which, since the earliest Middle Ages, put the town-halls of Belgium in opposition to the palace of the suzerain or his deputy.

The autocrat, steeped in the principles of Prussian militarism, imbued with the prejudices engendered by the narrow discipline of an army spread over the whole nation, could not fail to attack a monument which stood for a type in itself.

In the centre of this dead town, with its imposing dimensions and sumptuousness, it stood as an irrefutable witness to the victories all down the ages of the commune burghers and the guilds of artisans over the central power represented by the suzerain or his vassal, by the monarch or his governor. The communal spirit survived feudalism and all the following *régimes*, and still retains its tenacious influence in Belgium.

The Belfry and "Halles" of Ypres were bombarded and burnt by order of the same despotic and brutal will that determined the arrest and imprisonment of Burgomaster Max. These buildings typify the materialisation, and this man the incarnation of the same bold spirit of local resistance which the imperialism of a William II. could not tolerate on the path where he threw his servile hordes.

Such, then, is the meaning of this act of vandalism, which has once again impoverished the whole world by taking away one of its most significant *chefs-d'œuvre.*

Ypres, that magnificent town, has never been so much talked about as since she no longer exists. It is often thus with men, whose death brings them before the public, and whose celebrity is all posthumous. Up to that moment only the initiated knew the value of their mind or of their deeds, but circumstances never drew public attention to them. In the same way, Ypres had her group of devotees, but these were not very numerous and did not devote much literature to her monuments or her memories. Foreigners all knew Bruges, the Venice of the North—Bruges la Morte—who was only asleep.

Bruges was on the programme of every well-arranged trip to Belgium, but Ypres was far off and had less obvious charms. It was difficult to get to, trains did not fit in, there were many changes and much loss of time. The best way to go was by motor from Ostend, or one of the seaside resorts of the Flemish coast. And doubtless this was often done. It was a regular excursion for bathers. But they got there for lunch, and as they always wanted to be back at the sea for tea, the visit to Ypres was rather cursory. They were satisfied to drive through the Grand' Place, telling the chauffeur to go slowly. They did not go into any of the buildings, passed the Belfry and Cloth Hall, glanced sometimes at the Cathedral standing in the corner of the square, and, when leaving the town, admired the moat and the ruins of the old ramparts just as the car was gaining speed.

I need not say that this was not the way to visit this unique town, whose civic monuments were the grandest of any that the past had left us. Ypres was a drowsy town, a city of dreams and nostalgia. The number of its inhabitants during the last century was out of all proportion to its size. It had no longer any industries, and only the lace-makers in the doorways, shuffling the bobbins on their pillows, showed any activity in the dreary lassitude of their surroundings.

The Belgian Government had founded a school for cavalry officers at Ypres. The young men going through their course there brought a little noise and gaiety with them. In the summer, the owners of the country houses round came in on market days and also on Sunday morning to attend mass. Then there were motors, carriages, pretty frocks, meetings and gossip; for the country round Ypres was studded with country houses, villas and chateaux. Many rich Frenchmen had bought estates, farms or land there. They thought it safer to put their money into Belgian land, because they were alarmed by the threatened income tax and socialistic tendencies of the French Government. Alas! if they had known!

Since the beginning of the war, first the Belgians, then the French, but later chiefly the British, have defended Ypres, and this terrible salient of the Western front has cost the Allies innumerable young and precious lives. The German has never trodden the sacred soil of Ypres, but as the town was within range of his guns he destroyed it furiously, and practically has not left there one stone upon another.

There is also no doubt that the rancour and fury of the Kaiser and the German staff were partly the cause of this vindictive destruction. For, do not let us forget, the Belgian army had, for the third time since the commencement of the war, just prevented the realisation of the Emperor's plans.

The first time was at Liége when, under General Leman, they held up the invader for ten days. The second, at Hofstade, September 9th, 10th, 11th and 12th, when they obliged two army corps, which were marching on the Marne, to turn back. Without this diversion these troops might very probably have turned the tide of this decisive battle. The Germans recognised it, excusing themselves for not having foreseen such a possibility.

Dr. E. Jaeger, one of the most authoritative members of the Reichstag, wrote in the *Allegemeine Rundschau:* "If the Belgians had not stopped and held us by their obstinate

defence, we might have put at least five army corps more on the Marne, we should have won the battle and entered Paris. It was the resistance of the Belgians which prevented us from taking Paris and winning the war."

The third time was on the Yser. The Belgian army, exhausted by seventy-five days of campaign in which they had struggled alone, absolutely alone, against the German armies on the march to Paris and Calais, still heroically held on for ten days, helped by 6,000 French marines, against the shock of all the German forces and the full blaze of their artillery. This respite gave the French and British time to act. Calais was saved, but Ypres paid for this check.

At Ypres there was not only the Cloth Hall, the Belfry and the Cathedral of St. Martin, which have been so much talked of during the last three years; but those who knew Ypres, or had lived in its neighbourhood, know that in all the squares, streets, and even in the shadows of its alleys, were to be found houses and monuments dating from every period.

With the Belfry and "Halles" and Cathedral of Ypres, it is not only architecture that disappears. Buildings in their general structure can be restored. Their survival is only assured by repeated restoration. It is art, precious memories and history which sink and die.

Yes, history was written by painters on the walls, by sculptors in the stone or tombs and statues, by artisans in a thousand forms. The physiognomy and the soul of the old city are brutally demolished. Such losses, like those of the manuscripts and priceless books at Louvain, like the sculptures of the façade of Rheims, nothing can repair. They are final.

Before the war the lethargic town of Ypres spread over the low plain of Flanders, her towers and gables dominating the remains of her old ramparts, dismantled in 1856. She smiled on her reflection in the canals and ponds fed by the sluggish stream of Yperlée.

Gradually reduced since the twelfth century from a population of two hundred thousand souls to a number which did not reach twenty thousand, she still displayed everywhere the traces of her ancient splendour and her long prosperity. Like an ancestress, she drew a touching prestige from the inactive but wonderful charm of the past.

Ypres, in the course of the ages, had often been besieged. It was invested by the English in 1383, taken by the mercenaries of the Prince of Parma in 1584, taken and retaken by the French in the seventeenth century, and later by the armies of the Republic and the Empire; but Ypres never knew such barbarism and horror as that which, during these last four years, has ruined her for ever.

"Kultur" only could destroy so much beauty and so much art. As a fortified town, Ypres, throughout the centuries, had been spared. As an open town she was burnt and crushed, even to her museums and most precious monuments of the past.

Long ago the fullers and wool merchants of Ypres kept four thousand looms at work. It was at the expense of their corporation that the gigantic Cloth Hall was erected, which took more than a century to build.

The eloquence of the past was so persuasive at Ypres. The Grand' Place, wide and long as for a great population, the giant Belfry, the enormous halls, the immense Cathedral, appealed to the least sensitive imagination. And the old houses, once so sumptuous, proclaimed the evolution of styles in the art of building, from the façade of the Rue de Lille, the Boucherie Gothique and the antique "Gasthuis Belle," to the dwellings dating from the reigns of Louis XV. and Louis XVI., all telling how local life persisted and still flourished through so many vicissitudes. Nothing remains now of all these treasures.

I am going to show you quickly on the screen the progressive destruction of the monuments, the irremediable damage done.

Here is the Cloth Hall with the Belfry, those marvels of which a French author has written: "This monument, by its proportions, recalled the majesty of the cathedrals, by the beauty of its architecture the Venetian palaces, by the elaborated sumptuosity of its ornaments the buildings erected by the Spanish Moors." Here is a fragment of the "façade," showing the trefoils in the pointed arches of the "Halles" (Cloth Hall).

Now look at what the Hun did. This photograph was taken in December 1914. It shows a first state of destruction. Another striking picture, showing a view taken from a spot in the neighbourhood of the Museum, December 1914. Now we see the Cloth Hall and Belfry as they stood at the end of December 1916. The ruins were most impressive. This shows the frontage of the halls—the photograph was taken the same day as the former one. A picture of the *salle voutée*, April 1917 (there, in old days, was held the market). And this is the *ensemble* of the ruins as they stood in

June 1917, and they are still nearly in the same state to-day.

I told you that history had been written by our painters on the wall.

The present picture shows the interior of one of the painted galleries. Some frescoes dated from the fourteenth and fifteenth centuries. They had been rashly restored. The others had been executed during last century.

Guffens, Swerts, Pauwels, and the more majestic Delbeke, had portrayed there the great events of the town's history. Delbeke, in his frescoes at Ypres, had shown to the fullest extent an individual and curious talent. Nowhere else is there any really important work of his. He died relatively young, leaving this expressive series almost finished. Now there is nothing left of Delbeke's works, except a few sketches and unimportant little pictures. This painter, who was worthy of a high place in the modern Belgian school, has passed for ever into nothingness. When we think of the enormous interest taken in the smallest fragments of frescoes nowadays, we can well imagine the admiration which would have been expended in the future on this harmonious collection now so ruthlessly destroyed.

This is a view of the curious and little known "Gasthuis Belle" (almshouse, hostel). It was founded in the middle of the thirteenth century by Salomon Belle, Seigneur de Boesinghe, and his wife Christine de Guines. The family of the "Seigneurs de Boesinghe" is not extinguished nowadays.

The "hospice Belle," among numerous antiques and curiosities, possessed a very precious triptych by Melchior Broederlam, Court painter to Philip the Bold, Duke of Burgundy, from about 1382 to 1401. This work of the predecessor of the Van Eycks is a document of the highest interest painted by the old Ypres ancestor of the Bruges school. With charming simplicity, though already using good technical means, he has painted the Virgin and Child between the donors accompanied by their patron saints.

The Virgin Queen, sweet and dainty, crowned with gold, is dressed in red and gold brocade. Yolande Belle, granddaughter of the founders, and her husband Jean Bride, the donors, surrounded by their sons and daughters, are painted on the wings. Jean Bride is accompanied by St. George, in bizarre armour, Yolande by St. Catherine. They have dwelt in the hostel since the fourteenth century throughout all other wars and vicissitudes.

My learned friend, Baron Kervyn de Lettenhove, showed the old triptych at the first of the three celebrated exhibitions of Old Masters he organised in Belgium, the "Primitifs Flamands" and "La toison d'or" at Bruges, Belgian art of the seventeenth century at Brussels. These three exhibitions drew a large crowd of foreign visitors, and even the German Emperor, his Empress and their only daughter, came to see the wonderful art treasures filling the third. The Kaiser was amongst the exhibitors; he had lent pictures savagely restored—I mean ruined—by German professors.

He probably made a note of what he intended to loot later on in Belgium; but that day, although he seemed frightfully anxious about a possible attempt on his life, and ordered the public to be carefully selected and drastically kept far from him, he spoke to us only of art and peaceful prospects.

The triptych by Broederlam, I am glad to say, has not been destroyed with the hostel. That most rare and invaluable masterpiece, prior to the discovery of oil painting, was removed when only slightly injured by the bursting of a distant German shell. It is now kept in Paris, with a great number of other relics saved from the part of Belgium which is under range of the German guns.

The Belgian Minister for Science and Art had early in the war taken steps to transfer in safety all valuable things that could possibly be removed. The "Mission du Ministère des Sciences et des Arts" has done marvels, and even under the bombardment our agents have saved invaluable treasures. It is only a small part compared with what Belgium has for ever lost.

The director of the mission, the well-known architect Eugène Dhuicque, is responsible for the greatest part of the photographs I show to-day. I am glad to express here my gratitude for his help. Others are lent to me by M. Butaye, who used to live at Ypres and cherished his town with filial feelings. But let us come back to the monuments.

After the Cloth Hall with the Belfry, I will show you the Cathedral of St. Martin, which was a huge and splendid Gothic church. The interior was crowded with memorials. Among those I quote, just for a memento, the flowery Gothic monument erected to the memory of Louise de Laye, widow of Hugonet, Chancellor of Burgundy, and the tomb of Antoine de Henin, and the stone covering the remains of Jansénius, Bishop of Ypres, the austere founder of Jansenism.

The magnificent rose-window is in atoms, and the triumphal arch constructed in 1600 by Urban Taillebert, overthrown. And the rood-screen with alabaster statuettes, the pulpit so exuberantly sculptured, the choir-stalls—a model of woodcarving—and the painted vaulting are all burnt up.

I next show views of the nave and the steeple in 1915; interior of the choir, 1915; the transept, north side, 1915; another sight of the steeple (it is the western side), 1915; view of the exterior and steeple in 1916; interior of the Cathedral, 1916; last sight of the steeple in 1917. Finally the steeple collapsed in 1917, on Good Friday, at eight o'clock in the morning. The Boche can be proud of his deeds.

Now I am going to evoke a few of the odd and charming old corners that made Ypres so fascinating. This is the "Ancienne hall à la Boucherie," a very old and picturesque building, used as a museum. It is the oldest church of Ypres—older than the Cathedral of St. Martin—St. Peter's (a Norman building, the "Portal" dating from the eleventh century). Interior—at the bottom are the remains of a huge altar of the seventeenth century. This belongs to the sixteenth century, "L'ancien Béguinage."

You know the silent and lovely Flemish béguinages—those of Bruges, Ghent, Dixmude, Lierre, and so many others have been so frequently reproduced by the artists. They were peaceful, like anterooms of heaven.

A shop, Rue de Dixmude: an old and quaint shop of which you can see a picture in the book by Henri Hymans "Bruges et Ypres," in the series published at Paris under the title "Les villes d'art célèbres."

Now the seventeenth century at Ypres. The *nieuw werk*—it means the new work; you see how Flemish and English are sometimes related. It was built on one side of the Cloth Hall. School of St. Francis, Rue de Dixmude: a picturesque frontage. This is the same after the Mission du Ministère des Sciences et des Arts had removed every stone of this frontage whose destruction was certain. The stones are numbered, and it will be possible to reconstruct later on the building exactly as it stood. The lovely statue of the Virgin (carved in wood) has been saved.

Now we come to the eighteenth century, which had dowered Ypres with numerous lovely houses. The Musée Merghelynck. The Hotel Colaert: these are the remains of the outhouses. It is in the same style as the beautiful Hotel Merghelynck, of which nothing remains. The town house of Chevalier Hynderickx, Rue des Chiens The gate of the same: British soldiers on the threshold.

Even the nineteenth century had left a few nice buildings in Ypres. I am sorry I cannot show you—the slide has been broken—a lovely pavilion constructed by the painter Delbeke, the man who painted on the Cloth Hall walls, at the bottom of his garden, overlooking the River Yperlée. The ruin is a charming picture.

"La Visite de la Reine." Those are slides showing Her Majesty, the Queen of the Belgians, amongst the ruins of the unfortunate town. And so, you see, Ypres is no more.

You have seen all that is left of the famous square at Ypres, of which Michelet, in his book "On the Roads of Europe," wrote so justly:—

"The Grand' Place of Ypres, though for other reasons and under more austere skies, is worthy of being as precious to mankind, as sacred, and as intangible as the Piazza San Marco in Venice, the Piazza della Signoria in Florence, or the Cathedral Square of Pisa. It is a unique and irreproachable monument of art."

And see what the Germans have made of this spot, so precious, sacred and intangible. Are they not also now trying to destroy Venice?

As my compatriot Jean Dardenne writes: "Those who systematically destroyed the Grand' Place of Ypres, and those who approved of its destruction, have morally ceased to belong to the human race, they have descended the scale of being to a rung somewhere between savage beasts and asses. . . . Emperor William will share with Nero the glorious infamy of having premeditated and committed such execrable crimes against civilisation."

Alas! Ypres, sad martyr, your casket of buildings has lost the dear old cloister with its flamboyant arches; the quaint "conciergerie" built in the seventeenth century in Renaissance style, which everywhere else was out of fashion; the charming "sister's workrooms" at the hospice St. Jean; the gabled façades of the old Abbey of Thérouanne; the tower of St. Nicholas; the Hotel Merghelynck, enclosing a museum of the eighteenth century, furniture and ornaments; and the churches and ancient city gates, and the old houses—all these touching and picturesque relics of the past.

Even if there shall be anything left among the ruins and *débris*, the wounds and outrages inflicted by the enemy on our ancestor city can never be effaced. Art, history, tradition, and legends have flourished there, and are abolished.

The crime of those who willed this annihilation can find no excuse.

Ypres was the largest, the most precious and beautiful of the Flemish cities crushed by the Hun. Many others also—towns or villages—had kept the remains of old prosperity and artistic splendour. All those villages whose unknown names suddenly became famous by the terrific battles raging there—Pervyse, Reninghe, Ramscapelle, Steenstraete, Bixschoote, Het Sas, Elverdinghe, etc.—had huge Gothic churches, town-halls, and relics of the past worthy of universal admiration.

The heart of our old and dear Flanders was still alive in so many drowsy towns, under the shadow of their towers and their gigantic trees. Nieuport, Dixmude, Furnes, like Bruges and Ypres, were full of treasures. The two first are no more, the latter is still standing, wounded, partly blown up, so moving in her distress and agony.

We are now going to review quickly a few of their sights. First the villages.

This is Loo, which had a splendid old church and very good private houses that had stood for centuries. Church: a picture showing the hole caused by a shell in the wall of the apsis; the steeple is still untouched. The vestry. The church has suffered much. Interior of the nave. The steeple has been overthrown. This picture was taken immediately after the fall of twenty-seven bombs in the sanctuary. The German gunners had enjoyed a good time.

Woesten, a village five miles from Ypres. It has been defended by the Belgians, the French, the British, the French again, and the British once more. The shelling never ceases there. This is the church—another view of devastation.

Neuve-Église. Another beautiful church not far from Messines. It dated from the fifteenth and sixteenth centuries, and was burned in the first weeks of the war. It has been shelled without intermission since.

This is Dixmude. The ground where she stood is still in the hands of the Boche. She has been absolutely smashed. I can give only a few views of the past, just to show how picturesque she was and what we have lost.

A bridge over the Yser. This view has been painted and engraved a thousand times by our artists, as well as a spot not far distant called "La maison du juge." Dixmude had also a lovely béguinage, full of beautiful flowers smelling sweet in the summer sun, and much praised by our artists. What has become of the shy and timid nuns who were living so peacefully, far from the world and its vanities, in this delightful convent? This is the magnificent altarpiece by Jacques Jordaens, one of his masterpieces; it has been burnt to ashes. And this is the celebrated screen, immense, and carved as delicately as an old Chinese ivory or reliquary; it has been smashed to atoms.

This is Nieuport, a very old town too, near the mouth of the Yser. In her close neighbourhood was Nieuport-bains, a seaside resort. This is the old church which formerly, surrounded by large trees, was a beautiful picture of the past. Interior of the choir: two columns only are still standing. The old Calvary in the cemetery; graves of French soldiers; at the bottom the ruins of the church. The "Halles" and Belfry —what is left.

And this is Furnes. A view of the beautiful Grand' Place, town-hall, law courts, belfry A passage under the town-hall, 1915. View of an old Flemish town: the apple market; in the bottom the Church of St. Walburge, 1915; a house standing on the left side, still untouched; the same house destroyed at the corner of the apple market—a few days after.

Corner of the Grand' Place. Interior of the Church of St. Walburge: the splendid stalls carved in oak by Urbain Taillebert. They have been dismounted and removed by the Mission.

The Grand' Place again: King George, with King Albert and the Prince of Wales, watching the troops parading.

You have seen now a slight part of what Belgium has lost of her artistic and historic treasures. You will agree with me that when peace comes no money will repay such irremediable losses. The only way to restore, as much as is practically possible, our national inheritance, is to give back to our museums all the splendid works of art executed during the past centuries by our artists on our soil and which are now the principal features of the German and Austrian museums. We want to retrieve from the Kaiser Friedrich's museum at Berlin the wings of the celebrated altarpiece of Ghent, "The Adoration of the Lamb," painted by the brothers Van Eyck, in order to see, in its former state again in the Cathedral of Ghent, that wonderful masterpiece of the inventors of oil-painting. We want to retrieve from Vienna a few pictures by Peter Breughel the old, that thoroughly Flemish master, one of the most interesting artists of our school from the technical point of view, as well as by its popular humour. And from Vienna also the altarpiece painted by Rubens, for the Royal Church of St. Jacques sur Caudenberg in Brussels, a special commission

given to the artist by the Archduke Albert and his wife Isabella of Spain, who presented the picture to their parish chapel. And from Frankfort the panels of the Master of Flemalle, of capital importance for the history of old Flemish art, and from Munich, and from Dresden, and from Cassel, and from so many other places the principal pictures, statues, tapestries, wood-carvings, bits of furnitures—all created on our soil by our own artists and craftsmen.

Those things would be in the future--for us and for our foreign visitors—a slight compensation for the loss of our monuments and their contents.

Martyrised Belgium deserves to become a unique museum, and a pilgrimage for all the lovers of art.

I trust that the Allies, and specially the Belgian diplomatists, will not forget the point when discussing at last the peace terms with the hated Boche.

I am ready to supply them with a full list of paintings and works of art that we want only to complete the representations of our own glorious Old Masters in our national museums. All our British friends will come and admire them in Belgium, again free, and—let us hope—flourishing!

The Chairman (His Grace the Archbishop of Canterbury), in moving a hearty vote of thanks to the author for his clear and eloquent paper, said its interest was pathetic, and the sympathy it had inspired profound, and the indignation which underlay the feelings of those who had heard it was not easily restrained. The author had mentioned that the physiognomy of Ypres had been demolished, and he feared that was so, but the spirit remained of a city which had inspired the heroic resistance which had been displayed by Belgium against the ravages of the enemy, and it was to be hoped that that spirit would be seen again in the full exercise of ingenuity and forcefulness and progress in the days to come. He asked the author to accept not only the thanks of the meeting for his paper, but also an expression of their sympathy, their admiration, and their gratitude for the nation and people of Belgium, to whom this country owed so much.

Mr. Alan A. Campbell Swinton, F.R.S. (Chairman of the Council), seconded the motion, which was carried unanimously.

His Excellency the Belgian Minister said the presence in the chair of the Archbishop of Canterbury was an honour which he appreciated deeply, and he was sure that he could speak for all present when he offered his Grace their warmest thanks. He would like to say especially how much the Belgians present appreciated the honour; nothing could show better how the sufferings and the trials of the Belgian people were still the object of sympathy in England, and nothing could emphasise more strongly the high moral principle for which the Belgian cause stood in the war. It was not only at the present time that his Grace was interested in Belgians in England and in invaded Belgium, for he had given many proofs of his constant and active sympathy; but the presence that afternoon of the highest authority of the Church of England was of special significance. What had the author shown so clearly? The mutilation of the works of art designed to elevate the soul and help it to attain its ideal; the destruction of the riches of a past, with its memories of work, of tradition, of faith, and of prayer; the devastation of a peace-loving land, the seat of an ancient and high civilisation, where a hard-working and honest population hoped to fulfil their destiny, ruled by the noblest religious and æsthetic ambition. That destiny, which might be called a dream if it had not known centuries of reality, had been brutally and pitilessly brought by German aggression to a sad termination. But civilisation could never die, any more than right could be silenced or liberty oppressed for ever. In the ruins which had been shown there was a promise of resurrection. The monuments of Ypres had not been destroyed in vain; for the splendid deeds, of which Ypres had been the theatre, had erected a monument of heroism which no German shells could destroy. The sons of Great Britain and Belgium would come to Ypres as pilgrims, when right had been vindicated by the complete restoration of Belgium, to render thanks for the sacrifice of thousands of British heroes who died there for the cause of justice and civilisation. He offered the thanks of the meeting to his Grace for presiding, for the support of his high spiritual authority, and for the encouragement of his cordial sympathy.

The Chairman, in thanking the Belgian Minister for his remarks, said that the meeting might help to keep alive and stimulate just those thoughts to which His Excellency had given such eloquent expression. If those present went away from the meeting with such thoughts in their minds, they would feel that, sad as was the story to which they had listened, and the pictures which they had seen, even the destruction of so many beautiful monuments might not have been in vain if it meant the resurrection of something greater.

The meeting then terminated.

STEAM NAVIGATION ON THE UPPER YANGTZE.

Steam navigation on the Upper Yangtze—that is, above Ichang—is attracting much attention, and is proving very profitable to the operating companies. The Szechuan Steam Navigation Co., the oldest firm now operating steamers on

this section of the river, runs the steamers "Shu-tung" and "Shu-hun," both of which were built in Great Britain, and have proved that it is possible to navigate successfully the upper river. Another ship, the "Ta-chuan," owned by the Szechuan Railway Steam Navigation Co., has successfully completed its third year's service. For the journey of 400 miles between Ichang and Chungking the cost of sending freight is from about £3 10*s.* per ton upward, depending on the nature of the cargo. The cost of a first-class passage by the steamship "Shu-hun" is £8 for the up-river journey, and £4 for the down-river trip. The up-river journey takes from three and one-half days in the case of the "Shu-hun," to five or six in the case of the other ships. The down-river journey is made in two days, and passenger and freight rates are accordingly lower.

In July, 1916, the steamship "Lien-hua," belonging to the Teh Yu Steamship Co., which is registered in Hong-Kong, made its trial trip to Chungking. On this run certain machinery defects were developed which necessitated its return to Shanghai for alteration and repairs.

In October the "Chu-chuan," owned by the Szechuan Railway Steam Navigation Co., made its maiden trip to Chungking, accomplishing the journey in six days. This vessel is of the same type as the "Shu-hun" and is almost as large. It is 190 ft. over all, 30 ft. in breadth; draught, when loaded, 6 ft., and it has triple-expansion engines of an estimated horse-power of 1,000. The sister ship "Chi-chuan" is an exact counterpart of the "Chu-chuan."

Two ships, "I-chiang" and "I-chou" have been constructed at Shanghai for the Wanhsien Shang Pau Min Chiang Steamship, Co., Ltd. These steamers are said to be about 130 ft. long. Besides these ships, the Standard Oil Co., of New York, and the Asiatic Petroleum Co. have each one ship under construction at Shanghai. These ships, in all probability, will be devoted solely to the transportation of the products of the owners.

In 1916 the three steamers, "Shu-tung," "Shu-hun," and "Ta-chuan" did not resume their services until July, and later in the case of the "Ta-chuan." This delay was due to political conditions. In 1917 the steam navigation season was expected to open with eight steamers on the Ichang-Chungking run, in addition to the vessels of the oil companies. Still further expansion is probable.

A steamer service between Chungking and Suifu has been maintained since the middle of 1916 by the "Jui-yue," a small boat. During high water this vessel went as far as Chia-ting Fu, on the Min River, about 300 miles west of Chungking. The "Yuan-chi," another small steamer, has arrived from down river for service above Chungking. Two other vessels, the "Ching-yue" and "Ching-an," which had been operated in certain seasons both below and above Chungking, have been condemned by the Customs authorities, and probably will not again be seen on the upper river. Vessels plying above Chungking are operated under the Inland Waters Navigation rules.

The next few years, writes the United States Consul at Chungking, will undoubtedly witness considerable expansion in steam navigation above Ichang. It is expected that competition will reduce freight rates somewhat, but so long as navigation is attended with a considerable amount of risk, rates will remain relatively high. There are certain conservancy schemes under contemplation for the improvement of navigation. Were a sufficient sum of money made available for conservancy work, undertaken under the direction of expert foreign engineers, the navigation facilities of this section of the river could be greatly improved, and probably made possible for twelve months in the year.

COFFEE EXPORTATION FROM COSTA RICA.

According to an official publication, the total exportation of coffee from Costa Rica during the season August, 1915, to April, 1916, was 37,134,182 lb. gross, or 33,853,707 lb. net, of which 66·34 per cent. was fully treated, and 33·66 per cent. was with the parchment covering. The coffee shipped "in parchment" has had the fermentation and the drying processes, but no other: it is called "pergamino," while that fully machined is called "beneficiado." In calculating the net weight, a reduction of 18 per cent. is made for the parchment-covered coffee, and there is also an allowance for tare. How this quantity compares with exports in preceding seasons the following table discloses:—

Season.	Pergamino.	Beneficiado.	Total.
	lb.	lb.	lb.
1906-7	21,639,978	16,556,275	38,196,253
1907-8	12,392,989	7,399,076	19,792,065
1908-9	12,050,261	14,471,575	26,521,836
1909-10	18,397,415	13,342,370	31,739,785
1910-11	17,086,045	10,782,929	27,868,974
1911-12	13,036,539	13,943,354	26,979,893
1912-13	10,774,461	17,927,647	28,702,108
1913-14	19,035,512	20,023,932	39,059,444
1914-15	12,619,062	14,291,345	26,910,407
1915-16	12,498,004	24,637,178	37,134,182

Of the amount exported in 1915–16, it appears from a report by the United States Consul at

San José that the United Kingdom took 50·20 per cent., the United States 42·19 per cent., and the remainder was sent to France, Spain, Italy, Panama, and Chile. Almost half of the entire production is from the Province of San José.

man, woman, and child in continental United States.

The rate of growth as disclosed by the nine official censuses of manufactures taken between 1849 and 1914 (both inclusive), is shown in the following tabulation:—

Year.	Number of Establishments.	Wage-earners. (a)	Capital.	Wages.	Cost of Materials.	Value of Products.	Value added by Manufacture.
			Dollars.	Dollars.	Dollars.	Dollars.	Dollars.
1849	383	1,733	1,035,551	458,904	1,691,824	3,040,671	1,348,847
1859	541	2,340	1,568,478	688,423	2,990,186	5,361,100	2,370,914
1869	949	5,825	4,995,293	2,091,826	8,703,560	15,922,643	7,219,083
1879	1,450	9,801	8,486,874	3,242,852	17,125,775	25,637,033	8,511,258
1889	2,921	21,724	23,326,799	7,783,007	31,116,629	55,997,101	24,880,472
1899	962	26,866	26,319,000	8,020,453	35,354,208	60,643,946	25,289,738
1904	1,348	36,239	43,125,000	11,699,257	48,810,342	87,087,253	38,276,911
1909	1,944	44,638	68,326,000	15,615,388	81,150,773	134,795,913	53,645,140
1914	2,391	53,658	97,467,000	21,472,000	101,015,000	170,845,000	69,830,000

(a) Average number.

GROWTH OF AMERICAN CONFECTIONERY INDUSTRY.

To meet the American consumption of sweetmeats the year 1916 required between 175,000,000 and 200,000,000 dollars' worth of factory-made confectionery, and this in addition to the vast amounts of cocoa and chocolate other than confectionery that were consumed and to the home production of "taffy," "fudge," and other bonbons.

According to a statement recently published by the United States Department of Commerce, the confectionery industry of the United States has expanded with great rapidity. Sixty-five years ago less than 400 establishments were needed to supply the American demand for factory-made sweets. Their aggregate capital was little more than 1,000,000 dollars, and the value of their products not much over 3,000,000 dollars. On the basis of a population of 23,200,000, this meant an annual per caput expenditure of only 13 cents (there being practically no foreign trade in confectionery then). To-day, assuming that the industry has maintained during the last two years the same rate of growth as in the five-year period 1909–1914, the industry embraces over 2,500 establishments, represents the investment of 110,000,000 dollars capital, and turns out confections of various sorts having a total value of 185,000,000 dollars. On the basis of a population of 102,000,000, this means a net expenditure of 1·80 dollars a year for every

These figures reveal an increase of 524 per cent. in the number of establishments from 1849 to 1914; one of 2,996 per cent. in the average number of wage-earners; 9,312 per cent. in the capital invested; 4,579 per cent. in wages, 5,871 per cent. in the cost of materials; and one of 5,519 per cent. in the value of the products.

In the census returns the classification of "confectionery" covers the manufacture of all kinds of candy and confections, cake ornaments, popcorn balls or cake, chewing gum, salted nuts, stuffed dates, etc., but not the operations of establishments making primarily chocolate, cocoa and similar products, which are classified under the census designation of "chocolate and cocoa products." Prior to 1899 the statistics for the industry included the returns of the numerous small retail makers of confectionery, which accounts for the great decrease in the number of establishments between 1889 and 1899.

The American consumer much prefers his own American-made candy to the confections of other lands. Imports of foreign confectionery have never been large, and with few exceptions have been quite overshadowed by the exports; this the table below shows. Because of the diversity of sources from which the data were obtained, the "year" used in this tabulation is: For production, the calendar year; for imports and exports, the fiscal year ended June 30th; for population, the calendar year

following the one named, *i.e.* 1850, 1860, 1870, etc. :—

Year.	Production.	Imports.	Exports.	Population. (*a*)	Per capita Expenditure.
	Dollars.	Dollars.	Dollars.		Dollars.
1849	3,040,671	461	(*b*)	23,191,876	0·131
1859	5,361,100	1,243	(*b*)	31,443,321	0·171
1869	15,922,643	12,344	5,583	38,558,371	0·413
1879	25,637,033	6,537	32,274	50,155,783	0·511
1889	55,997,101	36,643	151,685	62,947,714	0·888
1899	60,643,946	31,797	603,170	75,994,575	0·790
1904	87,087,253	82,259	551,911	(*c*) 82,574,195	1·049
1909	134,705,913	80,953	716,727	91,972,266	1·459
1914	170,845,000	294,019	1,329,147	(*c*) 98,781,324	1·719

(*a*) Population of United States exclusive of outlying possessions.
(*b*) Not separately stated. (*c*) Estimated.

NEW PROCESS IN HAWAIIAN SUGAR INDUSTRY.

The invention of a new process for the recovery of sucrose from final molasses, which would mean a gain of at least 3½ per cent. in the commercial sugar crop of the Hawaiian Islands, is reported by the correspondent at Honolulu of the United States Department of Commerce. The inventor is Mr. J. N. S. Williams, who is field engineer to an American firm in the islands. The new process takes from the so-called "final molasses" approximately one-half of the 8 per cent. of sugar that heretofore has been considered an absolute loss. The additional cost for machinery will be slight, says Mr. Williams, but in the long run it will involve no additional cost to produce 3½ per cent. more sugar by the new process than is now taken from the juice in the production of second, third and fourth sugars. The process, he claims, will produce in one operation what now takes three operations, and at the same time will yield the additional sugar.

Mr. Williams's experiments with this process have extended over two years. The results, as summed up, are that final molasses boiled to 99 per cent. Brix will develop small grains representing practically the whole of the sucrose present in the molasses, that this grained sucrose can be recovered in large quantities with suitable equipment, and that this recovered sucrose may be converted into a marketable product.

The principle on which Mr. Williams has worked is that it is not the glucose gums or ash, but solely the water in molasses that has prevented the sucrose therein from crystallising. Removing the water, then, is the only method by which it can be made to give up its sucrose, he believes. This is the first step in the process—boiling the molasses to a practically complete absence of water.

The next important departure in the new process is the use of a high-speed centrifugal. On this point Mr. Williams explained that he had used a centrifugal built in 1905, which has been run to a speed almost twice as great as centrifugals ordinarily show. It is added that specially built centrifugals and apparatus for breaking the hard massecuite probably were the only machinery items on which there would be added cost.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

Dogs' Wool.—Industrial people have little time to spare over materials only available in very small quantities, and the discoverers of the utility of lap-dogs' "wool" will command more patience when they can offer it in parcels of some thousand pounds' weight. If the hair of dogs has not been used hitherto for making warm knitted comforts, the hair of rabbits certainly has. Hair plucked or combed from the Angora rabbit has been used, especially in France, for making light and costly wrappers for use in winter sports. Hair from most animals has been used in manufacture. The domestic ox in dying leaves a hair largely used in the pile of the cheapest plushes and sometimes in knitted underwear. The camel, the reindeer, the goat, and animals frankly unknown to those who use their produce, all furnish hair for one textile purpose or another. A distinction may be recognised between the pure purposes in which hair approximately all of the same kind is used to make relatively fine goods and the coarsest purposes known to commerce. Coming down to the dregs of manufacture, it can be said there are no questions asked. Given merchantable length and strength, the fibre goes to the blend that will make

the cheapest rugs or blankets. It is to be inferred that the British Dogs' Wool Association aims at producing from particular types of hair goods comparable with those made from wool of particular types of sheep, *e.g.* Iceland and Shetland.

Mixed Goods.—Perhaps the greatest technical advance made during the war has lain in the manipulation of mixed wool and cotton. Mixed yarns spun upon cotton machinery in imitation of French mule-spun worsted began to be produced in 1914, and their employment has spread because their character has been admired, and because of the need of economising wool to the utmost. The success attained in concealing the cotton must be as near perfection as it is likely to get, and is near enough in the best examples to deceive the senses of men who have been handling goods made from pure fine wool all their lives. The progress made in these delicate adjustments of old processes may well prove commercially more important than changes involving wider departures from established practice. The wool dress goods of the future will bear the marks of this experience for many years to come.

"Plains" and "Fancies."—It would have been acceptable to have the reports of the Committee on Textiles in considerably more detail, and it is to be supposed that before these can be published *in extenso* the situation confronting the industry may be materially different from that of 1916. The extracts published by the Board of Trade lose authority from a manner of publication which divorces them from the trains of thought in the evidence of witnesses. Regarding the general question of standardisation, we get the conclusion that the advantages of large-scale production are fully reaped in all staple branches of textile industry, but not in the minor branches of the large industries or in the silk, lace and cotton hosiery trades. The pronouncement covers a wide diversity of trade circumstances. The smaller trades commonly buy yarn which has been manufactured upon a thoroughly economical scale, and they are seen as a "host each making a small quantity of a multiplicity of articles, all making more or less the same articles each with separate buying, producing and selling organisations, all costing money and swelling overhead expenses." It is agreed that the difficulties are considerable, for fancy articles depend upon fashion for sale and lose their value when standardised or indefinitely multiplied. They are, indeed, fairly expensive articles to make, whether manufactured under one control or by numerous parties, and economy is best consulted in making only the right ones for the time. There is little doubt that the buyers of fancy goods value the freshness that comes of a multiplicity of origins, and they are accustomed to trace the inevitable family likeness in articles coming from one source. It is palpable, however, that the committee had in view the practice of making a little of everything—plain as well as fancy—and it is common experience that plains can most advantageously be made by standardised methods. Hitherto, however, plain textiles have not been as uniform as one might think. Some small and apparently immaterial feature is seized upon and demanded by customers here and there, so that even the maker of plain cloths works upon a surprising number of patterns and finds it profitable to do so.

Trade Combination.—Cartels are rather vaguely mentioned as affording a partial solution of the problems of standardisation in Germany, and cartels, or something like them, are held up as the hope of the silk, lace and hosiery trades. Makers of these goods are advised by the committee to try combination and co-operative selling in the foreign markets. It is advice to which manufacturers assent more readily in theory than practice, and it is to be observed that cartels are rarely found in any country except under stress of severe circumstances. Whether conditions after the war will favour independent action remains to be seen. There is an evident probability that collective action will be more imperative in some directions than in others; more, perhaps, in securing supplies and labour than in disposing of goods. At any rate for a period after the conclusion of peace, business can hardly need the stimulus of novelty of design.

Capital Outlays.—Shareholders in one of the woolcombing companies have been reminded that an immense sum will be required to put the plant and machinery into the same state of efficiency as in normal times. Depreciation has gone on fastest in the mills that have been most furiously worked, but it can be taken as a general rule that replacements or renewals of productive machinery are a good three years in arrears. When the work comes to be done the cost will inevitably be heavy, and the pressure upon machine-makers coming from foreign as well as home customers will exceed anything hitherto known. When it is understood that a spinner is asked 37*s.* 6*d.* for machinery that he last bought at 13*s.*, the influence upon capital outlay is manifest. Facts like this lend weight to the contentions advanced by manufacturers as to the need for special consideration at the hands of the tax-gatherers. Manufacturers wish to have left to them money to cover the expenses of replenishment, and exceedingly few of them will care to carry the cost of new plant at its full value in their books in the future. They will strive to write down the book values to some level approaching the normal, and the authorities will assuredly be pressed to countenance them in that prudent course. It has been the salutary ambition of most private textile enterprises to assume a low value for the mill and its contents, and it used to be true before the rise in values that cotton-mills which could not be built for five times the money stood in the books at 5*s.* per spindle. The utility of this drastic writing-down appears when the inevitable bad times are reached.

OBITUARY.

The Hon. Sir Sundar Lal, C.I.E.—Information has been received of the sudden death in India of Sir Sundar Lal in his sixty-first year.

Sir Sundar was leader of the Allahabad Bar, and he had also served the University there for many years, being at the time of his death its Vice-Chancellor. He had long represented the University on the Provincial Legislature, and was also a member of the Viceroy's Legislature. The successful organisation of the Benares Hindu University was due in no small measure to his energy, and he was its first Vice-Chancellor. He was also the first Indian to be appointed to the Bench of the Judicial Commissioner's Court of Oudh, and he was also for a time a Judge of the Allahabad High Court.

He was elected a Life Member of the Royal Society of Arts in 1901.

GENERAL NOTES.

M. Paul Lambotte's Lecture.—Fellows of the Society who were unable to be present at the meeting on March 13th will have another opportunity of seeing the remarkable series of lantern-slides shown in illustration of the appalling devastation wrought by the Germans in Ypres and its neighbourhood. M. Paul Lambotte, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, will repeat the lecture, which he delivered before the Society, at Kensington Town Hall on Tuesday, April 16th, at 5 p.m. The chair will be taken by the Mayor of Kensington, Alderman Sir William H. Davison, K.B.E., D.L. The proceeds of the lecture will be devoted to the Kensington Red Cross Hospital.

Formation of Diamonds.—For the past thirty years the Hon. Sir Charles Parsons has been conducting experiments on the formation of the diamond. The results of his work in this field of research—work which has a direct bearing on many branches of pure and applied science—are to be made known for the first time at the eighth annual May Lecture, which he is to give before the Institute of Metals on May 2nd. In view of the special character of the occasion, the Council of the Institute of Metals have decided to make this an open meeting. Those desiring to be present should apply, enclosing a stamped and addressed envelope, for cards of invitation to Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, S.W. (1)

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m. :—

April 17. — Frank Stuart Courtney, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England, "Agricultural Machinery." Dr. J. A. Voelcker will preside.

April 24.—Sir Major Robert Armstrong Jones, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons in Social and Medical Reconstruction." The Right Hon. Lord Sydenham, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

May 1.—George Martineau, C.B., "Sugar from several Points of View." The Right Hon. Lord Balfour of Burleigh, K.T., G.C.M.G., G.C.V.O., will preside.

May 8.—John B. Farmer, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

May 15.—Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

May 29.—Martin O. Forster, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." Sir William A. Tilden, D.Sc., LL.D., F.R.S., will preside.

Indian Section.

Thursday afternoons, at 4.30 p.m. :—

April 18.—Alfred Dickinson, M.Inst.C.E., "Water Power in India." The Right Hon. Lord Lamington, G.C.M.G., G.C.I.E., will preside.

May 30.—Hon. Sir Dinshaw E. Wacha Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

Colonial Section.

Tuesday afternoon, at 4.30 p.m. :—

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana." Sir Everard im Thurn, K.C.M.G., C.B., will preside.

Cantor Lectures.

Monday afternoons, at 4.30 p.m. :—

J. Young, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day."

Syllabus.

Lecture II.—April 15.—Other high-explosive mixtures and their uses — Chlorate mixtures — Nitro-cellulose and nitro-glycerine, and mixtures containing them—Military smokeless powders.

Lecture III.—April 22.—High explosives used for shell filling—Methods of detonation—Initiators of detonation — Tests applied to explosives — Miscellaneous.

Special Lectures.

A special course of three lectures on "The Freedom of the Sea" will be delivered on Thursdays, May 2nd, 9th, and 16th, at 4.30 p.m

LECTURE I.—By GERARD FIENNES. Chairman, J. L. GARVIN.

Syllabus.

THE FREEDOM OF THE SEAS.

Freedom without Law. — The first maritime peoples—The Viking Age—Edward III. and the sovereignty of the seas—The Hansa—The Italian Republics in the Mediterranean.

Law without Freedom.—The discovery of the passage round the Cape of Good Hope and of America—The Bull of Alexander VI.—Henry VII.'s licence to the Cabots—Elizabeth's views—The English and Dutch—The war of Jenkins's Ear—The mercantile system—Berlin decrees—Orders in Council.

Law and Freedom.—Britain's work—Freedom "made in Germany."

LECTURE II. — By SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., Chief Justice of Hong-Kong, 1905-12. Chairman, LORD SANDERSON, G.C.B., K.C.M.G.

Syllabus.

THE FREEDOM OF THE SEA IN WAR.

The breakdown of International Law due to unpractical theories—Effect of war on the Freedom of the Seas—Limitations of neutral commerce with the enemy—Rule of 1756—All interference with neutrals based on prevention of assistance to the enemy—"Free ships, free goods": the neutral doctrine essential to maintain the enemy's fleet—Foundation of a spurious Freedom of the Sea claimed by enemies and neutrals: consistent opposition to the doctrine by England—The armed neutralities—American War of Independence—Bonaparte's theories—Immunity of private property at sea—Declaration of Paris—Maintenance of English principles of belligerency essential to an effective League of Nations.

LECTURE III.—By JOHN LEYLAND. Chairman, The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S.

Syllabus.

THE GERMAN "FREEDOM OF THE SEAS."

Britain the great upholder of the Freedom of the Seas—The meaning of the term—How it was regarded by Grotius—How we came to be denounced as the "tyrants of the sea"—The attitude and policy of Napoleon—His claim to be the liberator from tyranny—The modern German claim a protest against British sea-power—An analysis of the claim—Its real meaning—The view held and expressed in the United States—The agreements and understandings with Prussia—President Wilson's declaration—How it is in conflict with the German claim—The need of a right understanding of the subject.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 15 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. J. Young, "Military Explosives of To-day." (Lecture II.)

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Rev. Canon J. A. MacCulloch, "The Gnostic Conception of the Cross."

Engineers, Cleveland Institution of, at the Literary and Philosophical Society, Middlesbrough, 7.30 p.m.

Geographical Society, Kensington-gore, W., 5 p.m. Mr. G. T. McCaw, "Resection in Survey—the First Problem."

TUESDAY, APRIL 16...Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. Professor W. M. Bayliss, "Light and Vision: the Physiology of the Retina."

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Drs. A. E. Dunstan and F. B. Thole, "Relation between Viscosity and Chemical Constitution of Lubricating Oils."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m.

Japan Society, 20, Hanover-square, W., 3.30 p.m., Mrs. W. Weston, "Fuji San Old and New."

WEDNESDAY, APRIL 17... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. F. S. Courtney, "Agricultural Machinery."

Meteorological Society, at the Institution of Civil Engineers, Great George-street, S.W., 5 p.m. 1. Mr. E. G. Bilham, "The Variations of Underground Water-level near a Tidal River." 2. Mr. J. Fairgrieve, "Suggestions as to the conditions precedent to the occurrence of Summer Thunderstorms with special reference to that of June 14th, 1914."

Geological Society, Burlington House, W., 5.30 p.m. Mr. A. E. Trueman, "The Evolution of the Lifaroceratidæ."

Literature, Royal Society of, 2, Bloomsbury-square W.C., 5.15 p.m. Lecture by Professor W. de la Mare.

Electrical Engineers, Institution of (Local Section), University, Birmingham, 7 p.m. Mr. E. C. McKinnon, "Large Batteries for Power Purposes."

THURSDAY, APRIL 18...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Mr. A. Dickinson, "Water Power in India."

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. Professor J. P. Hill, "Narrative of the Percy Sladen Expedition to Brazil in 1913."

Chemical Society, Burlington House, W., 8 p.m. Lecture by Sir Henry Miers.

Royal Institution, Albemarle-street, W., 3 p.m. Lieut.-Colonel C. S. Myers, "Present-day Applications of Experimental Psychology." (Lecture II.)

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 6 p.m. Mr. L. Andrews, "Overseas Distribution of Engineering Appliances."

Mechanical Engineers, Institution of, Storey's-gate, Westminster, S.W., 8 p.m.

FRIDAY, APRIL 19...Royal Institution, Albemarle-street, W., 5.30 p.m. Major G. I. Taylor, "The Use of Soap Films in Engineering."

SATURDAY, APRIL 20...Royal Institution, Albemarle-street, W., 3 p.m. Professor E. H. Barton, "Musical Instruments Scientifically Considered." (Lecture II.)

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REGISTERED AS A NEWSPAPER.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 22 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cantor Lecture.) Mr. J. Young, "Military Explosives of To-day." (Lecture III.)

Geographical Society, Burlington - gardens, W., 8.30 p.m. Miss M. H. Mason, "The Transkei."

Tuesday, April 23...London Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 5 p.m. Rev. Canon Carnegie, "St. Margaret's Church, Westminster."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "Barrow Explorers." (Lecture I.)

Civil Engineers, Institution of, Great George-street, S.W., 5.30 p.m. Annual General Meeting.

Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Dr. J. A. Murray, Report on the Deaths in the Gardens during the Year 1917. 2. Professor Wood-Jones, Exhibition of specimens illustrating the effects of Rickets.

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Professor Commendatore Attolico and Captain F. Giannini, "The Industrial Position of Italy."

Wednesday, April 24 ... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Major Sir Robert Armstrong-Jones, "Mental Effects of the War and their Lessons in Social and Medical Reconstruction."

Sanitary Institute, 90, Buckingham Palace-road, S.W., 5 p.m. 1. Mr. F. Baines, "Housing: Planning and Materials, Permanent and Semi-Permanent." 2. Mrs. Sanderson Furness, "Housing: Fitments and Conveniences."

Colonial Institute, Caxton Hall, Westminster, S.W., 4 p.m. Lieut. C. H. S. Reis, "The Remarkable Development of Argentine Agriculture."

Thursday, April 25...Royal Society, Burlington House, W., 4.30 p.m.

Cold Storage and Ice Association, at the Royal Society of Arts, John-street, Adelphi, W.C., 5 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Isambard Owen, "Rheims Cathedral." (Lecture I.)

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Mr. E. C. McKinnon, "Large Batteries for Power Purposes."

Concrete Institute, 296, Vauxhall Bridge-road, S.W., 5.30 p.m. Mr. J. H. Deane, "The Charterhouse Street Cold Stores of the Port of London Authority."

Friday, April 26...Royal Institution, Albemarle-street, W., 5.30 p.m. Sir A. Daniel Hall, "Food Production and English Land."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Saturday, April 27...Royal Institution, Albemarle-street, W., 3 p.m. Professor H. F. Newall, "Modern Investigations of the Sun's Surface." (Lecture I.)

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FRIDAY, APRIL 19, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 22nd, at 4.30 p.m. (Cantor Lecture.) J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day." (Lecture III.)

WEDNESDAY, APRIL 24th, at 4.30 p.m. (Ordinary Meeting.) SIR MAJOR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons in Social and Medical Reconstruction." The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

Monday afternoon, April 15th; MAJOR-GENERAL SIR DESMOND D. T. O'CALLAGHAN, R.A., K.C.V.O., in the chair. Mr. J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, delivered the second lecture of his course on "Military Explosives of To-day."

The lectures will be published in the *Journal* during the summer recess.

SEVENTEENTH ORDINARY MEETING.

Wednesday afternoon, April 17th; DR. J. A. VOELCKER in the chair. A paper on "Agricultural Machinery" was read by Mr. FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England.

The paper and discussion will be published in the *Journal* of May 10th.

INDIAN SECTION.

Thursday afternoon, April 18th: The RIGHT HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., in the chair. A paper by Mr. ALFRED DICKINSON, M.Inst.C.E., on "Water Power in India" was read by Mr. E. S. WOOLLARD MOORE Assoc.M. Inst.C.E.

The paper and discussion will be published in the *Journal* of May 17th.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, March 14th, 1918; The RIGHT HON. J. AUSTEN CHAMBERLAIN, M.P., in the chair.

The paper read was—

ENGLISH COMMERCE WITH INDIA, 1608–1658.

By WILLIAM FOSTER, C.I.E.,
Registrar and Superintendent of Records, India Office.

The calendaring of the India Office records has now reached a point from which it is possible to look back upon fifty years of British trade in the East. It was a period of many experiments and many failures; but by its close, so far as India itself was concerned, the trade had settled down upon the main lines on which it was conducted, with striking success, during the remainder of the seventeenth century. The subject is a complicated one, for the operations of the East India Company's servants extended from Arabia and Persia on the west to China, Japan, the Philippines, and the Moluccas on the east, while many of the lines of traffic were interwoven in a somewhat confusing manner with the direct trade between India and England; and since the time at my disposal will not permit me to survey the whole field, I have thought it best to confine myself to the consideration of the actual exchange of commodities between our own country and its future dependency. This is the aspect of most interest to a British audience, and it is one

concerning which little is to be found in the ordinary text-books.

It is a matter of common knowledge that a direct commerce with the Indian peninsula was not the main object of the East India Company at the time of its establishment in the year 1600. The immediate aim of its promoters was to compete with the Dutch in fetching from the Malayan Archipelago the pepper and spices which were so much in demand in the Europe of that day. Consequently the goal of the Company's fleets was for long the port of Bantam, in Java, which was at once a good centre for pepper and a convenient starting-point for the further voyage to the Spice Islands. It was, however, quickly discovered that English commodities were in small demand in those parts, while, on the other hand, the products of India, especially calicoes, found eager purchasers; and thereupon it was arranged that the outgoing fleets should call at Indian ports, in order to dispose of their European goods and to procure in return some more suitable for the Far Eastern markets. From this resulted the foundation of factories—as the Company's commercial establishments were termed—in the dominions of the Mogul Emperor of Northern India, particularly at Surat, the chief port of Gujarat. This was in 1608, and a few years later trade was opened up for a like purpose on the other side of India, where a factory was settled at Masulipatam, the chief port of the independent kingdom of Golconda. The latter commerce was for long entirely subservient to the needs of the Bantam market; it was not until 1629 that a vessel was sent direct from England to the Coromandel Coast, and none went home from thence until twenty years later. As regards the trade with Western India, the next stage was for one or two of the outward-bound fleet to turn back at Surat, carrying home Indian and Persian products, while the remaining vessels went on to Bantam. This development took place in 1615, nearly seven years after the first arrival of an English ship at an Indian port; and that date may be taken as the real commencement of the direct trade between the two countries, though already many English commodities had been sent out for sale in the Mogul's dominions, while a certain amount of Indian products had reached the home markets by way of Bantam.

When the Company's servants at Surat had to decide what goods to send for England, their choice naturally fell in the first place upon indigo, which was already in some demand in Europe for dyeing purposes. By far the most important English export was woollen goods (chiefly broadcloth), and the making, dressing, and dyeing of these formed the chief industry of the nation. Blue was a favourite colour; yet a suitable dye was not easily obtainable. For a long time the principal agent employed was woad, of which considerable quantities were imported from the Continent for that purpose. As an alternative, logwood for a while came into favour, but although this afforded a wide range of tints, its colours could not be fixed, and on this ground its use was forbidden by Act of Parliament in 1581 and again in 1597.* In the meantime a more satisfactory substitute had been found in indigo, which was brought from India to Lisbon by the Portuguese and from Turkey to London by the ships employed in the rising trade with the Levant, and was in some demand, not only in England, but also in France and other Continental countries. So promising did this new commodity appear to be that in 1582 we read of instructions being given to an English traveller to endeavour to procure in Egypt some indigo plants or seeds, with a view to their being acclimatised in England. Hence it is not surprising to find that in 1615 the "Hope" took home from Surat over 1,400 bales of indigo, procured chiefly at Ahmadabad. The rest of her lading consisted of calicoes, cotton yarn, carpets, ginger, aloes, etc.

Thenceforward indigo became the principal constituent of the cargoes sent home from Surat. The chief centres of supply were Sarkhej, near Ahmadabad, and Biana, near Agra. The methods of manufacture in these districts were different, the result being in the case of the former a coarse kind of indigo, often much adulterated, while the Biana variety was hard and of a superior quality. The distinction was known in London some years before the arrival of the "Hope," for in April, 1609, we find the East India Company writing that Sarkhej indigo was

* Acts 23 Eliz. c. 9, and 39 Eliz. c. 11. The prohibition was not formally removed until 1662 (13 & 14 Chas. II. c. 11). It seems, however, to have been disregarded, for in July, 1615, a certain Richard Giles obtained a patent authorising him to enforce it by seizing and destroying logwood wherever found. The East India Company naturally approved of his activities, as tending to encourage the use of indigo; and in October, 1617, they gave him £20 towards his expenses, while in the following July they agreed to pay him a regular tariff on all his seizures. They also induced the King to issue a proclamation threatening punishment to all concerned in the use of logwood; and a further proclamation to the same effect appeared in 1636. The statement made by some writers that the use of indigo was prohibited by Act of Parliament appears to have been due to a confusion with the ban placed upon logwood.

then worth 5*s.* a pound, while the Lahore kind (by which they meant the Biana indigo, which then came mostly overland from Lahore) was fetching 8*s.* When once the importation by the Company had become established, these prices dropped to about 5*s.* 6*d.* or 6*s.* for the Biana variety, and 4*s.* or 4*s.* 6*d.* for that from Sarkhej. In March, 1646, when the dyeing industry was doubtless disorganised by the Civil War, the Company wrote that these rates had gone down to 4*s.* in the one case and 3*s.* 4*d.* in the other, and that, unless an improvement took place, the indigo would have to be of specially good quality to be worth importing. Some nine years later the price had improved to about 4*s.* for Sarkhej and nearly 6*s.* for Biana indigo. Besides these two kinds, we hear of a medium quality obtained from Sind from about 1638 onwards; in 1646 this was fetching 3*s.* 4*d.* a pound, and two years later 2*s.* 8*d.* Some indigo received from the Coromandel Coast sold in 1644 and 1645 for a little over 1*s.* 3*d.*, and in 1657 for 1*s.* 5½*d.* It was evidently of a very inferior quality.

The comparatively high price fetched by this article led to an attempt in England to utilise indigo dust (bought at a cheap rate from the Company) by working it up into an imitation of the ordinary balls or cakes. In July, 1634, William Bolton obtained a patent for this process, much to the indignation of the Company, whose remonstrances were so vigorous that in the following December the patent was cancelled. It is worth noting that Bolton alleged that the Biana indigo, as sold by the Company, was too hard for general use, and that his patent covered a process by which this was soaked and ground down, being afterwards made up, with the addition of indigo dust, into a substance more nearly resembling Sarkhej indigo. The latter kind, by the way, was the one most favoured by English dyers, though they admitted that one pound of the Biana variety went as far as a pound and a half of the Sarkhej indigo.

The prices at which the indigo was purchased in India varied according to the abundance or deficiency of the crops, and the amount of competition on the part of buyers. To avoid the enhancement due to the latter cause, the Dutch and English merchants on several occasions combined to buy in common, though at other times the competition between them was severe. On an average the cost appears to have been about 1*s.* a pound. Gerard Malynes in 1623 put it at 1*s.* 2*d.*, and the average proceeds in England at 5*s.* At either rate, allowing 2*s.* or 2*s.* 6*d.* for shipping and other charges, there was still a fair margin of profit. In 1652 we find the Surat factors writing to the Company that indigo "hath heretofore bin your most gainefull comodity."

The adulteration to which indigo was subjected by the makers, particularly by the admixture of sand and earth, led to many complaints from the Company. The Surat factors in 1644 explained that this was a long-standing practice, the object being to give greater consistency to the indigo. As their employers were still unsatisfied, the factors in 1646 bought a quantity of indigo leaf themselves, and had it manufactured under their own superintendence; but though the quality was improved, the cost was, if anything, higher than if the indigo had been purchased in the usual way, and after a second attempt, two years later, the experiment was abandoned.

A large proportion of the indigo imported by the Company was sent to the Continent, much of it going to the Mediterranean for sale in Southern France and Italy, while a certain quantity found a market at Hamburg, Danzig, and even in Holland, though the Dutch were, of course, bringing their own supplies from India. In 1625 it was stated that the merchants of the Turkey Company, who at one time had regularly imported raw silk, indigo and spices into England from the Levant, were now actually buying those goods in London, and carrying them to the Mediterranean. This re-exportation of indigo continued down to the end of the period with which we are dealing, in spite of the wars that were waged with various Continental powers in the time of Charles I. and the Commonwealth.

Meanwhile the Company's trade in this article was already being threatened with competition from the West Indies. As early as January, 1633, mention is made in the Court Minutes of some indigo from Guatemala having been brought into England from Spain; and later on the English planters in the West India Islands, as well as in Carolina and Georgia on the mainland, cultivated the plant with some success, though, according to Macpherson ("European Commerce with India," p. 201), they were never able to produce indigo equal to that of Guatemala or of San Domingo. All these competitors had a great advantage over the East India Company in the cost of transporting their produce to the European markets, and during the latter part of the seventeenth and the early part of the eighteenth centuries the importation from India was limited to the

better qualities, grown in the Agra neighbourhood and purchased at Surat. The anarchy that set in after the death of Aurangzeb doubtless restricted the supply and enhanced the cost; and after the year 1724 the Company omitted indigo from the annual list of commodities to be purchased. In 1729 the Bombay Council sent home (unasked) a large quantity, which could only be sold at a very heavy loss; and thereupon the directors peremptorily forbad any further dealing in the article. For half a century indigo ceased to figure among the Company's imports; and then a change in the situation made it once more an object of interest. About the middle of the eighteenth century its cultivation in the West India Islands was abandoned—according to Macpherson, because of a high duty imposed upon it, but Sir George Watt suggests that the real reason was the higher profits yielded by sugar and coffee. This left the markets to the Americans and the Spaniards, and both sources of supply were stopped in 1775 by the War of Independence, in which Spain took sides against Great Britain. The consequence was a revival of the demand for the Indian commodity, and the establishment, about 1779, under the Company's auspices, of a flourishing indigo industry in Bengal. The subsequent history of this is well known.

Returning from this digression, we have now to examine the second branch of the Company's importations from India in the early days, viz., the cotton goods generically termed at home calicoes. In this case there was little or no existing demand for the commodity. The ground was occupied by the linens imported from France, the Netherlands, and Germany—as still evidenced by the names of hollands, silesias, lawns (from Laon), and cambrics (from Cambrai). The British and Irish linen industries were as yet non-existent, and so the gradual displacement of the foreign linens by Indian calicoes was viewed with complacency, particularly as a large proportion of the latter were re-exported—a traffic which, beginning with Turkey (where cotton goods were, of course, well known), spread gradually into other countries which had hitherto used linens. In August, 1623, the Deputy-Governor of the Company (Morris Abbot) reported a conversation which he and Mr. Thomas Mun had had with King James, who asked "what vent they had for the greate masse of callicoes [that] came yerelye. They answered that much of it is very usefull and vendes in England, whereby the prizes of lawnes, cambrickes, and other linnen cloth are brought downe; for the rest, England is now made the staple for that comoditie, which having first served His Majesties dominions, the overplus is transported into forrayne partes in the nature of a home bredd commoditie. The King approoved exceedingly thereof, and said that this was the ready way to bring treasure into his kingdome." In the following April Abbot (now Governor) declared that, whereas formerly England paid to the foreigner for hollands, lawns, and cambrics £500,000 per annum, now half of this outlay was saved by the importation of calicoes; and about a year later he told the Company that "the commodities of Zuratt doe vend heer much better then in former tymes; for example . . . callicoes . . . hath found such vent in forreyne parts as, if the Company had 100,000 or 200,000 peeces, they wold bee uttered in short time."

By 1630 the Company were ordering from Surat 100,000 to 120,000 pieces of white calico alone. Then came the depopulation of Gujarat by the terrible famine of 1630–32, which ruined the trade for a time, as calicoes became too dear for the London market.* In October, 1636, the Company wrote that the absence of supplies had "caused our linnen drapers here to find out other sorts of cloath to supplie the wants of their accustomed sorts of callicoes," and consequently "our callico trade hath suffered much in its wonted use and expence, and will require some tyme to bring that commodity into worth and reputacion againe." Eighteen months later they declared that all sorts of calico were out of favour in England, and that those bought were chiefly used for "dyeing into colloures." However, as time went on the industry gradually revived in Gujarat; while the opening up of English trade in Sind (1635) provided a fresh source of supply of good and cheap calicoes, and there was also a steady importation into England of piece-goods from the Coromandel Coast, which found favour in France and other Continental countries.

One effect of the famine of 1630–32, in which so many skilled weavers perished, was a great deterioration in the quality of the cloth produced; and this again operated unfavourably upon the demand in Europe. Writing in November, 1641, the Company declared that calicoes had hardly yet recovered their former

* Owing to the heavy charges incurred for shipping and factors, besides expenses at home, the Company held it necessary to realise three times the prime cost of their calicoes, if they were to be considered profitable.

reputation, lost by the poor making and bleaching of previous consignments, while the enhanced price made it difficult to compete in the London market against "the Germanie, Scotch, and French lynnens." The difficulty was aggravated by the general depression of trade which set in about 1640, and was intensified by the Civil War that followed; and the Company, finding no demand for the calicoes sent home, repeatedly distributed them to its members by way of dividend, leaving the recipients to get rid of them as best they could. By 1653 the demand had revived, possibly owing to the stoppage of linen imports as the result of the war with Holland; and in September of that year the Company wrote to the Surat factors to send as many calicoes as they could procure. Then came the period of open trade, when private English ships resorted freely to Indian ports in defiance of the Company's privileges. The resulting competition forced prices up in the East and down in Europe. However, the grant of a fresh charter by Oliver Cromwell in 1657 improved the Company's prospects, and we leave them confident of a great future for the trade in calicoes—a confidence which was soon justified.

It is interesting to note how the endeavours of the Company and its servants to procure calicoes of suitable dimensions and quality broke against the conservatism of the Indian weaver. At the beginning of 1628 the Surat factors wrote that they had tried in vain to secure the more substantial making of the cloth. The weavers objected, on the score that more yarn would be used, while the price of the finished article would not increase in proportion, adding that they could sell all they made in their usual fashion to other buyers, if the English did not want them. Some twenty years later the Company demanded cloths of special lengths and breadths; but again the makers demurred, pointing out that such goods would not easily find a market elsewhere, if rejected for any defect. Numerous complaints from London show that the calicoes provided varied considerably in size and in quality, while no improvement could be secured, because the demand in India from other and less fastidious quarters was sufficiently great to warrant the producers in refusing to alter their traditional methods.

Before passing from the subject of cotton, something may be said regarding the references to cotton yarn and raw cotton that occur in the Company's records at this time. Yarn was a fairly constant article of import from 1615 onwards, partly for export to France and Holland, and partly to meet the home demand. From 1616 to 1628 the price obtained by the Company was about 2*s.* 6*d.* a pound. In the latter year no less than 525 bales came home from Surat; and in March, 1630, the Company wrote that they could sell from 600 to 700 bales yearly. Then came a check. The Gujarat weavers objected to the English merchants competing with them for yarn, and combined to withhold their cotton cloth until the factors agreed to stop their buying; while on top of this trouble came the great famine. In spite of this the supply was kept up and good prices were realised in England. The Company wrote in November, 1641, that "of late workemen here have found many uses" for the yarn, and that the finer qualities were much in demand. In 1650 orders were sent out to reduce the supply, with the result that in 1652–55 we find prices at home ranging from 4*s.* to 4*s.* 4*d.* the pound. Then came a drop to the old level of little more than half-a-crown, probably because of heavy importations by private traders.

Raw cotton, or cotton-wool, figures at the Company's sales as early as November, 1621, but it was merely "packing wooll," which had apparently been brought home wrapped round the bales of piece-goods for their better protection, and it fetched only 6*d.* a pound. In 1622 an order was sent to Surat for a special supply, with the result that we find sales effected in 1624 at 14¼*d.* and in the following year at 13*d.* per pound. Some difficulty was experienced as regards stowage aboard the ships, since the commodity was too bulky to waste space upon it, if more profitable goods were available. In 1628, and again in 1636, the Surat factors urged that implements should be sent out for compressing the bales (as was done, they said, in Turkey); but no notice was taken of these suggestions, and the cotton continued to be sent home, if at all, loose in the hold, much to the detriment of its condition when received. By this time the manufacture at Manchester of goods, such as fustians, in which cotton was mingled with other materials, had become well established. The cotton used for this purpose came, however, from Cyprus and Smyrna. With a commodity at once so cheap and so bulky, the cost of freight was the most important factor in the sale price; and it was probably for this reason that the Company made no attempt to compete with the Levant traders. For the remainder of the period with which we are dealing, the sales at the East India House of raw

cotton were only of small quantities originally used in packing, which fetched from about 4*d.* to 15*d.* per pound, according to its condition and the momentary demand for it. The omission in 1650 of cotton-wool from the list of goods in which private trade was prohibited is a further proof of the small importance attached by the Company to this article of commerce.

Raw silk is the next item on our list of the Company's imports. The efforts made by James I. to encourage the manufacture of silk in England are well known, and to the demand for the raw material the East India merchants responded at first by importing Chinese silk from Bantam. In 1616, however, their servants succeeded in establishing trading relations with Persia, where large quantities of silk were produced in the provinces bordering upon the Caspian Sea. The sale was a royal monopoly; but the Shah was eager to prevent the traffic from passing through the dominions of his enemy, the Turkish monarch, and he welcomed with effusion the overtures made by the English, and later by the Dutch, for its diversion to an all-sea route. The first consignment went home from Surat in 1619, and sold for 26*s.* 10*d.* the great pound of 24 oz. As the cost in Persia was only from 8*s.* to 9*s.* a pound, this yielded a handsome profit, and the Company showed some eagerness to develop the trade. In 1622 Persian silk to the value of £93,000 was received from Surat, and in the following year this figure rose to £97,000. Much of the silk seems to have been exported to France, Italy, and the Low Countries, in spite of competition from that brought overland from Persia to Aleppo, as well as from that imported direct into Holland. However, the Persian officials made the most of their opportunities by debasing the quality and raising the price; and in January, 1625, it was noted that the cost in Persia was now 12*s.* 6*d.* per pound, while the proceeds in England were not more than double that figure. The Dutch, moreover, were competing vigorously in its purchase, and probably their imports were lessening the demand in England for export to the Continent. In November, 1626, the Surat factors pointed out that their other goods yielded more profit than silk, and advised that their colleagues in Persia should abstain from further purchases, remitting instead to Surat, for investment there, any money realised by the sale of English goods. Evidently, however, a certain quantity of silk still went home, but the price dropped gradually to 15*s.* a pound, on a prime cost of 10*s.* 6*d.*, and the Company in 1641 forbad any further investment. As already noted, this was a period of general depression of trade in England, and such an article of luxury as silk was bound to feel its effects. By 1648, however, prices had risen again, and orders were sent out for a fresh supply; while, during the war with Holland in 1652–54, as much as 27*s.* 6*d.* and 28*s.* per pound was obtained in London for the small quantity of Persian silk brought home. By July, 1656, the price was down again to 18*s.* 8*d.*; and, writing to Surat in March, 1657, the Company said that raw silk was in small demand.

In addition to Chinese and Persian silk, the Company during this period imported a certain quantity from Bengal. As early as 1619 some samples, procured at Agra, were sent home from Surat; and these crossed a letter from the Company, in which the factors were encouraged to furnish a good supply, provided that the silk was obtainable in long skeins and at a cost of not more than 7*s.* a pound. In reply it was stated that supplies were not regularly available at Agra, and that the silk was mostly in small and short skeins which it would be unprofitable to rewind. The despatch of a couple of merchants from Agra to Patna in 1620 gave an opportunity for fresh investigations. They reported that silk could be provided at a cost of about 6*s.* 6*d.* a pound, but that none could be procured that came up to the Company's requirements in other respects. With commendable enterprise they started a workshop in which an attempt was made to wind the silk from the cocoon in the manner desired; but no success attended their efforts, and the recall of the factors in 1621 put an end to the experiment. The Company had already made inquiries from the Masulipatam factors whether Bengal silk could be obtained by that route; the reply was, however, unfavourable, and so for a time all thought of that commodity was abandoned. Peter Mundy, who was sent from Agra to Patna in 1632, expressed the opinion that raw silk could be purchased elsewhere of better quality and at lower rates.

The establishment in the following year of English factories in Orissa seemed to open up a prospect of procuring Bengal silk by a new route. In 1634 we hear of trials being ordered at home of two bales of that commodity; but as nothing more is said upon the subject, we may conclude that the results were unfavourable. Eleven years later some Bengal silk (probably in poor condition) was sold by the Company at the low price of 9*s.* 1*d.* per pound.

About this time the cessation of supplies from Persia seems to have revived interest at home in the silk of Bengal, for in 1647 a letter was addressed to Surat making fresh inquiries on the subject. Some samples, procured at Agra, were accordingly sent home, and fetched 18*s.* per pound of 24 oz.; but, writing early in 1650, the Surat factors said that they would refrain from further purchases, as they considered the Persian silk, the trade in which had now been resumed, to be equally profitable. The establishment of a factory at Hugli in 1651 enabled the merchants there to provide Bengal silk at cheap rates and to pick out the better qualities, with the result that in 1653 the Company were getting from 25*s.* 3*d.* to 32*s.* 3*d.* a pound. This appreciation, however, was probably due in part to the war with Holland, for by 1657 the price had fallen to 16*s.* To follow the subsequent development of this traffic, as factories were established at Patna and other places in Bengal, would carry us beyond our present limit; but it may be noted that, until improved methods of winding were introduced under the Company's direction, about the middle of the eighteenth century, Bengal silk found little favour in England, and its use was chiefly restricted to the manufacture of sewing silks and other items of haberdashery.

In manufactured silks the Company appear to have taken little interest, though some of the piece-goods imported consisted of mingled cotton and silk; while quilts, made often of both materials, figure in the early cargo lists. As regards other textiles, there was at first a considerable importation of carpets, either bought ready-made or else manufactured to order at Agra. In 1619, however, the factors at that place wrote: "We perceave, by experience of a few bespoken here, that the tardines, slownes, and poverty of the workemen to be such that it is endles labour to bespeake them, and those bespoken to cost dearer then others ready made," adding that, when finished, the carpets specially manufactured were neither so well made nor so good in colour as those imported from Persia. In subsequent years purchases were made by the factors in the latter country; but by 1628 the Company had forbidden further investments in this article, and from 1632 carpets were allowed to be brought home as private goods. It is perhaps unnecessary to mention that at this period Oriental carpets were chiefly used as tablecovers, not trodden under foot.

As regards pepper, for a long time the favourite sources of supply for England were Java and Sumatra, both because the cost was lower and because access to the pepper ports on the western side of India was rendered difficult by the hostility of the Portuguese. As, however, the Dutch hold on the Malay Archipelago tightened, the English East India Company became more and more desirous of obtaining Indian pepper, especially as its superior quality enabled a slightly higher price to be demanded at home. In 1622 and 1630 Malabar pepper was costing in India about 6*d.* a pound, which was more than double the price at Bantam; but it was shot loose into the ships' holds and the expense of freight was therefore small; while at home it realised from 1*s.* 7*d.* to 1*s.* 9*d.* per pound. The bulk of that brought to London was evidently re-exported. In 1631 one merchant purchased the whole quantity received, to the value of from £30,000 to £35,000, and two years later the bargain was repeated with another merchant, for the express purpose of sending the pepper abroad. The conclusion in 1635, at Goa, of a convention between the Viceroy and the English President of Surat, opened the Portuguese harbours to English ships, and facilitated access to the Malabar pepper ports. Courteen's Association, which was largely founded to take advantage of this agreement, at once started factories at Bhatkal and Rajapur, whence large quantities of pepper were sent to England. Not to be outdone, the Company ordered their servants at Surat to provide a good supply; but most of the pepper procurable there came overland from the Balaghat and was consequently dear; while, as prices at home steadily declined, the trade was soon deemed scarcely worth following. Between 1644 and 1650 the Company found it expedient to ship pepper to Italy, owing to the small demand in England itself. The competition of private traders lowered prices still further, and in August, 1657, the Company were getting only 7*d.* per pound. In the previous November it was stated that the consumption of pepper in England was less than one-fifth of the 7,000 bags imported annually; that its average cost in the Indies was 3*d.* a pound, which was raised to 10*d.* by shipping and other charges; and that the remaining 5,600 bags, if sold on the Continent, would realise £70,000 at 1*s.* 8*d.* per pound. Evidently in this, as in many other branches of the Company's trade, reliance was placed rather on the export market than on the actual home demand.

Of spices in general, India was rather a

consumer than a producer. Cinnamon was occasionally obtained by English merchants at some of the Malabar ports or bought surreptitiously from the Portuguese, especially when the frequent blockades of Goa by Dutch fleets prevented its transmission to Lisbon; but the conclusion of a truce between Holland and Portugal in 1641 put an end to this traffic. The renewal of the war in 1652 was followed by a sustained attack by the Dutch upon Ceylon. Colombo was captured in 1656, and the other Portuguese settlements in the island were quickly mastered, with the result that the cinnamon trade, like that in other spices, became virtually a Dutch monopoly. A coarse kind of cinnamon, growing on the Malabar Coast, was still procurable; and the dearness of other kinds of spices, especially during the Anglo-Dutch War of 1652–54, led to some demand for cardamoms, obtainable in the same localities, and realising in England from 3*s.* 4*d.* to 5*s.* 9*d.* a pound. In general, however, the English found it hopeless to compete any longer with their Dutch rivals in the spice trade.

From about 1628 saltpetre figures prominently in the cargo lists of the homeward-bound vessels. The Dutch had for some time imported from the Coromandel Coast this necessary ingredient of gunpowder, and it may seem strange that the English were so slow in following their example. It must be remembered, however, that saltpetre was under strict Government control in England, and could neither be exported without permission nor sold to any but the King's powder-maker. Students of the time know the strange expedients resorted to in order to meet the evergrowing demand. The chief source of supply was from soil impregnated with nitrogenous animal matter; and the saltpetremen (as they were called) were empowered to enter upon any premises and dig up any earth, especially in stables, dovehouses, etc., which was suspected to contain the precious material. To such an extent was this interference carried, that in 1625 a royal proclamation was issued, forbidding the paving of stables, etc., or the hindrance of any saltpetreman from digging where he pleased. The quantity thus procured was, however, insufficient for the needs of the powdermakers, and supplies had to be imported from Danzig and other places. In February, 1624, the Commissioners of the Navy urged the East India Company to imitate the Dutch in bringing saltpetre from India; while at the close of the same year the Master of the Ordnance declared that the royal mills could no longer furnish the Company with powder, and that, if they wanted a regular supply, they must set up their own mills and bring in their own saltpetre. Thereupon instructions were sent out to the Surat factors to arrange for a supply, and a consignment, procured at Agra and Ahmadabad, was accordingly despatched to England. Meanwhile, the Company had (1626) obtained a licence to establish mills for the manufacture of gunpowder for their own use. This proved an unfortunate speculation. The first mills, set up at Egham, were ordered to be removed, as the noise disturbed the royal deer in Windsor Forest; whereupon the Company rented some mills at Chilworth, near Guildford—a locality ever since associated with the manufacture of munitions. The King's powdermaker complained loudly of this infringement of his patent, and for a time the concession to the Company was withdrawn. Finally, in February, 1637, they assigned their lease to Samuel Cordwell, who had secured a contract from the King in the previous November; and thus ended the Company's concern with the manufacture.

In India some difficulty had been experienced in procuring saltpetre, since its export was forbidden on account of its utility for warlike purposes.* Usually a bribe to the local officials removed all obstacles; but in March, 1628, the English and Dutch factors at Agra were imprisoned for a time for having bought and transported saltpetre without express permission. Ten years later, the Company, finding that at home they were forced to sell their stocks to the Government at prices much below the market rate, ordered that a preference should be given to other goods; and, in obedience to these instructions, the Surat factors first reduced, and then ceased their purchases. In 1643, however, they recommenced sending home a supply, pointing out that saltpetre was now cheap, and was moreover very useful as ballast, being shot loose into the vessel's hold.

The civil wars in Britain, followed by hostilities first with Holland and then with Spain, naturally produced a great demand for saltpetre. At the same time fresh sources of supply were being opened up in India. The development of trade with Rajapur and other ports on the Malabar Coast enabled the Company's servants

* In 1646 Prince Aurangzeb, then Viceroy of Gujarat, strictly prohibited the exportation of saltpetre, on the ground that the gunpowder made from it might conceivably be used against Mohammedans. The restraint was continued until his recall and the appointment of a less scrupulous successor.

to procure large quantities at a reasonable cost, though the expense and trouble of refining it at Surat induced them still to rely in the main upon purchases in Gujarat or at Agra. The same difficulty was felt upon the Coromandel Coast. The Madras factors wrote in 1652 that they could obtain an unlimited supply of saltpetre in Bengal, but must send it home unrefined, unless they could obtain from Surat some copper pans for boiling it, the earthenware pans used by the Indian refiners being troublesome and ineffective. They added that the Dutch shipped annually from Bengal nearly 2,000 tons, buying it raw at Patna and refining it at Pippli. Then, as now, saltpetre was abundant in Bihar, and a letter of December, 1650, says that the price at Patna was only one rupee per maund, though carriage and customs nearly doubled the cost by the time the saltpetre reached Hugli. As the Patna maund seems to have equalled about 78 lb., while at home saltpetre was fetching from £4 to £5 per hundredweight, it is evident that the commodity, though a bulky one to transport, yielded a handsome profit, after allowing for all expenses, including refining; and the numerous private ships that resorted to Bengal and the Malabar Coast during the period 1655-58 made their returns largely in this article. In July, 1657, Maurice Thomson and his associates, who were prominent in this traffic, declared that they had imported from Patna large quantities of saltpetre, much of which, after the needs of the English Government had been satisfied, they had exported to France, Sweden, Hamburg, Holland, and Italy, and that they hoped to make London the chief magazine in Europe for this branch of trade. In November, 1657, however, a note from the Company's servants at Surat states that on their side of India the exportation of saltpetre had been stopped owing to the outbreak of civil war, which ended in placing Aurangzeb on the imperial throne.

The remaining commodities imported by the Company may be dismissed more briefly. Lac—either in the form of stick-lac for dyeing, or of seed- and shell-lac for miscellaneous uses—was sent home from Surat at intervals during the greater part of the period; while supplies came also from the Coromandel Coast, obtained mostly from Bengal or Pegu. Sugar—both palm sugar from Gujarat and cane sugar from Bengal (procured partly by way of Agra)—was brought to England with fair regularity, though the Company attached little importance to this commodity, as evidenced by their placing it, in 1632 and again in 1650, among the goods which might be imported as private trade. The price realised in London was at first about £4 per hundredweight; it rose as high as £6 8*s*. in 1650, but declined to £3 or less in 1657, owing, possibly, to the competition of West Indian sugar. Other miscellaneous imports were ginger, borax, myrobalans, and various drugs, such as aloes (originally from Socotra), olibanum, benzoin, cassia, and spikenard. Cowries (obtained from the Maldives) were brought to England in 1647-50, but not in any great quantity; they were sold, it seems, for export to Africa. Coffee was a regular feature of the Company's trade in the East, their ships fetching it from Mokha for sale in India or Persia or at Basra; but although samples had been sent home in 1628 (apparently in response to a request), it was not until the end of 1657 that the Company ordered a supply for England; and the first time that it figured in their London sales was in August 1660.

In the foregoing list we miss several items which to-day figure prominently in the export trade of India. Tea or jute or hides we should not expect to find. Wheat was carried from Gujarat to Goa, and even to Bantam, for the use of the Europeans there; while biscuits made at Surat helped to provision the English ships for their long homeward voyage; but, of course, no one dreamt of carrying the raw material to England. Tobacco was another article which it would not have paid to send home, in view of the competition of Virginia. Rice figures at times in the Company's London sales; but it seems to have come from Bantam—not from India.

We have now to consider the commodities which the Company sent to India for sale there. Of these the most important was woollen cloth, the preparation of which, as already remarked, then constituted the chief industry of this country. It need scarcely be said that broadcloth, for which the equivalent of from 21*s*. to 28*s*. or more per yard was demanded in India, was not likely to be purchased for wear by ordinary people. As a letter from Surat (February, 1615) observed, the Indians could make three suits of clothes for the price of one yard of English cloth. But the Emperor and his nobles used this material to some extent for apparel, and still more for elephant trappings or saddles for horses; and, the custom once started, the officials of the imperial household could usually be induced to buy a considerable quantity on behalf of His Majesty. Bright colours

were chiefly in demand, especially reds, greens, and yellows. It is interesting to note that in December, 1639, the Surat factors reported that, whereas Jahangir had always preferred scarlet cloth, his more orthodox successor, Shah Jahan, would wear none but green. Throughout the period, though the demand varied considerably (partly owing to the competition of Dutch cloth, which was often superior to that brought by the English), broadcloth was a stock article of export, both to Surat and to the Coromandel Coast.

The other English products carried out were mainly lead, tin, and at first iron, though it was soon discovered that English iron stood no chance in competition with the cheaper Indian article. Lead—used mainly for making shot, but also for conversion into the red oxide for decorative purposes—was in constant demand in all parts of India. At Masulipatam in 1630 it was yielding 150 per cent. profit. The Surat demand was estimated in 1616 and again in 1628 at from twelve to thirteen thousand maunds per annum; while in 1639 the factors at that place declared that they could sell to the Governor for the Emperor's use almost any quantity that could be brought. The lead was chiefly in pigs or bars; but it came also as sheet lead, wrapped round the bales of broadcloth, and in that form it was stated to be yielding, in 1626, about as much profit as the broadcloth itself—a profit estimated, two years later, at 40 per cent. English tin found at times a market; but it was always exposed to competition from the tin of the Malay Peninsula, which commanded a much better price; and after a while the Company ceased to send any out. The considerable demand in India for copper was largely met by imports from Japan, brought by Dutch ships; and although the Company twice at least included a supply in their cargoes, it was found to be unprofitable and was given up accordingly. Quicksilver, on the other hand, was a favourite article of export from England to India, in spite of the trouble caused by leakage, and throughout our period considerable quantities were regularly shipped. It seems to have been mostly converted into vermilion (of which, however, a separate supply was often sent), and then used for decorating buildings, sacred and secular, or for toilet purposes. Both the Portuguese and the Dutch brought quicksilver to India from China, while some came also from Europe by the Red Sea route.

Another favourite item of commerce was coral, obtained originally from the Mediterranean, though here again there was competition on the part of that brought by the more direct Red Sea route. It was much in demand for personal adornment; while in the Deccan, we are told, it was used for burning with the dead. In 1626, and again in 1630, the profit made at Surat on this article was about 60 per cent.; at Goa in 1642 a consignment yielded 90 per cent. advance; and at Masulipatam in 1636 it was estimated that coral costing in England 14*s.* 6*d.* per pound would realise 100 pagodas per maund of 26 pounds, or over 170 per cent. In 1640 this commodity was declared to be the most profitable of all those sent to India. About 1647, however, a change set in, and prices went down, owing partly to large supplies brought by the Portuguese and the Dutch; though in 1659 we find the Company still purchasing a quantity for export to India. Coral beads were sent out as an experiment about 1645; but the prices were found to be too high, as the Indian workmen could make beads from imported coral at a much cheaper rate; while some of those received were unsaleable because they had crosses on them. Amber beads, by the way, were a profitable commodity between 1619 and 1629.

If it seems strange that Mediterranean coral could be carried to India with profit by such a roundabout route, it is stranger still to find that elephants' tusks, of which the main source was Africa, formed an important branch of the Company's early commerce, though a more natural route was that from Mozambique and other East African ports to Goa. The explanation seems to be that the supplies received by the latter channel were too irregular and too small to meet the very considerable demand in India for ivory for carving and inlay-work. However, suitable tusks were not always procurable in London at prices that would yield profit in India. From 1630 the export of this commodity virtually ceased until 1648, when a consignment sent out fetched a higher price than usual. In January, 1652, the Surat factors told their employers that ivory would always yield a profit.

Besides these ordinary items of merchandise, the Company sent out, especially in the early days, sword-blades, knives, mirrors, and many other articles for sale at the imperial court, including jewels, tapestry, satins, damasks, cloth of gold, and trinkets and curiosities of all sorts. The swords sold fairly well, though a regrettable preference seems to have been manifested for those made in Germany. The tapestry, manufactured mostly at the works started at Mortlake

in 1620 by Sir Francis Crane, was at first very popular at court; but in 1628 the factors reported against further consignments, as such hangings were now produced in India itself of a more suitable size. Some specimens sent out about ten years later were returned because no buyer could be found; while in 1652 the Surat factors declared that such articles were difficult to sell, especially if they had imagery on them. In that same year the English merchants were still endeavouring to recover from the gallant Raja Chhatarsal of Bundi the value of some tapestry which had, unfortunately, caught the fancy of his grandfather over twenty years before; and it is doubtful whether the full amount had been paid when the Raja fell, fighting for Dara against Aurangzeb, in 1658.

Sir Thomas Roe, during his embassy to India, urged strongly the advisability of sending out valuable jewels, of which he was convinced the Emperor and his nobles would buy up to £100,000 worth yearly. However, it was soon discovered that Jahangir, at all events, was a keen bargainer for such wares, and that any jewels refused by him or by his principal courtiers were difficult to dispose of, as no one cared to risk displeasure by purchasing them. In 1628 the factors advised that no more jewels of an ordinary character should be sent out, though large and rich pearls or rubies might sell to advantage. Apparently, however, the Company did not care to take any further risks in this direction, and so the trade in such rarities was left open to private speculators.

In spite of the Company's efforts to find suitable goods with which to fill their India-bound vessels, they could not avoid sending out a far greater value in coin or bullion as well, if return cargoes were to be provided. Statistics of these supplies of treasure are not often available; but we know that in the first twenty-four years of their trade the values of goods and money respectively sent out to all their Eastern settlements were in the proportion of about seven to fifteen; while in five later years the consignments to India itself showed a still greater disproportion—viz., about two to seven. As is well known, this constant export of the precious metals was the cause of many and bitter attacks upon the Company, and they would gladly have avoided it if they could; indeed signs are not wanting that for this reason they were content to continue sending out certain commodities so long as their proceeds would cover the bare cost of so doing. The usual form in which this treasure was carried was foreign silver coins, especially Spanish reals of eight (which were generally of a high standard of purity), though German or Dutch dollars, Florentine crowns, and silver ingots were also taken out. Whether coined or not, this silver had, of course, only a bullion value, since it had all to be turned into rupees at the Indian mints before it could be made available for the purchase of goods. The Company's charter permitted only the exportation of foreign silver; but in 1626, when, in consequence of the war with Spain, Spanish reals could not easily be procured, a licence was obtained from King Charles to export foreign gold. In the following year English gold or silver was allowed to be used, if necessary; while, later still, there were several grants for the exportation of foreign or English gold. On the Coromandel Coast, and in Southern India generally, gold was the standard currency; and even in Northern India that imported by the English proved in general more profitable than silver. In passing I may mention that in 1628 the Surat factors declared that, of the various kinds of gold coins sent out, there was "none that vends readier or yeilds more proffitt then 20*s*. peices English coyne." A little later, however, they reported that the demand for gold had fallen off, and advised that for the future only one-third, or at the most one-half, of the treasure sent out should be in that metal. The famine of 1630–32 depreciated still further the value of gold, since no one could afford to hoard it, and much that had been put away was now brought out and spent upon food. However, gold continued to be in demand on the Coromandel Coast; and in 1644 the Surat factors wrote that it was once again in favour in their parts of India, as the Dutch had not of late brought any from China. There was, indeed, no falling-off in the exportation from England down to the end of our period; and the acquisition by the East India Company of the Guinea Company's settlements in 1657 was prompted by a desire to utilise in India the gold dust procurable on the western side of Africa, and thus to reduce the amount of coin or bullion sent out from home.

Before concluding, something may fitly be said regarding the volume of the trade during the period under review. Unfortunately, the information available is very scanty, and such statistics as exist are of little use for our purpose, owing to the fact that they seldom apply to India alone. The outward cargoes included supplies for Persia, and sometimes for other countries as well; while those sent home from

Surat similarly comprised goods from Persia, and, in a few cases, some that had come from Bantam. The following figures, relating to the vessels despatched to England from Surat may, however, be given. The only ship that returned in 1616 carried goods to the value of £15,670; in 1619 the figure was £36,000; and in the following year £28,000, one ship being despatched in each case. In 1628 no less than seven vessels went home, with cargoes amounting to £193,440; while the ladings of the three ships of 1629 cost £51,150. Three more in 1639 carried home goods to the value of £109,570, and the cargoes of the two that returned in 1643 were invoiced at £58,770. Between 1648 and 1652 (both years included) the total for nine vessels was about £196,700, and in 1654 the lading of the "Welcome" cost £13,800. The figures, however, vary so widely, and the information is so defective, that no average can be struck. A safer guide is afforded by the tonnage of the ships sent home, as on that point the evidence is more complete. First, we distinguish a period of six years (1615–20), during which one vessel returns yearly with an average burden of 500 tons. Next come eleven years (1621–31) of increased trade, during which twenty-five ships go home, of an average of 590 tons, making 1,340 tons of merchandise per annum. Then, as a consequence of the Gujarat famine, the exports fall off, and from 1632 to 1638 only one vessel is despatched each year, with an average of 730 tons of goods. A spurt is made in 1639–40, five ships being despatched in the two years; but this effort spends itself, and the year 1641 is a blank. After this comes the Civil War in England, the increasing pressure of competition by private traders, and the troubles over the renewal of the charter. As a result, during the period 1642–58 we find only twenty-one of the Company's ships leaving Surat for England in the seventeen years, giving an average of 550 tons of merchandise per annum; but to these we may add seven sent home from the Coromandel Coast, raising the average of goods imported by the Company from India to nearly 700 tons per annum.* These figures, it must be remembered, include goods from Persia, etc. Moreover, they relate only to the Company's shipping, and the amount of Indian merchandise thus imported into England was largely increased, first by the vessels employed by Courteen's Association, and then by those of private traders during the period when the East India Company's charter was in abeyance.

Placed beside those of the present day, these figures may seem quite insignificant, as indeed all statistics of that period look when compared with those of an age when commerce has been immensely stimulated by the progress of invention and the resulting facilitation of intercourse between distant countries. At the same time it must be remembered that there were many reasons for the tardy development of trade between England and India. Harassed at home by an insufficiency of capital, by competition on the part of other traders, and by the troubles of the Civil War—impeded abroad by the hostility of the Portuguese and the Dutch, as also by the arbitrary and oppressive attitude assumed at times by the governments of the countries into which it sought to penetrate—the East India Company was beset with difficulties throughout the half century with which we are dealing; and, moreover, it had to serve a long apprenticeship, and experience many disappointments, before the possibilities of commerce between the two countries had been fully explored. At the close of the period, however, we leave the Company firmly established, both in India and at home, with a new charter, ample funds, and a monopoly secured by including in its ranks the most strenuous of its competitors. The result was seen in the great development that took place during the second half of the seventeenth century, and steadily continued until the trade of the Company was merged into that of the nation generally.

[The discussion on this paper will be published in the next number of the *Journal*.]

* For purposes of a rough comparison, it may be pointed out that a modern cargo liner may bring home at one time seven or eight thousand tons of merchandise.

SILVANUS THOMPSON MEMORIAL LECTURE.

At the meeting of the Röntgen Society held on April 9th, Professor Sir Ernest Rutherford delivered the first Silvanus Thompson Memorial Lecture. He dealt with the important advances in our knowledge of the constitution of matter, resulting from the discovery of X-rays in 1895. This marks the commencement of a new epoch in physical science, for in the attempts which were immediately made to ascertain the nature of the unknown radiation, attention was directed to the study of radiation in general, and new phenomena were soon encountered.

A general investigation of the cathode rays and of the nature of the discharge of electricity through gases led to the discovery of the "electron" and to the putting forward of the "ionisation theory" by Sir J. J. Thomson. Townsend followed up the

initial work by his theory of ionisation by collision, and O. W. Richardson investigated the emission of ions from incandescent solids. All this work was originally of academic interest solely, but within the last few years the practical applications have been shown to possess immense value. These include the production of detectors and amplifiers for wireless telegraphy, electrical rectifiers and oscillators by which radiotelephony across the Atlantic is now possible, and the Coolidge X-ray tube, which is destined to play an important part in radiology and in pure science. From the outset X-rays and the phenomena of phosphorescence were generally thought to be connected, and Becquerel, while in search of "invisible" or X-radiations from certain phosphorescent salts, discovered the radioactivity of uranium compounds. The brilliant researches of the Curies, by which this discovery was followed, resulted in the isolation of the radioactive elements, polonium and radium. Numerous other radioactive elements were brought to light, and the chaotic condition which ensued was not reduced to order until the introduction of the transformation theory by Sir E. Rutherford. Difficulties regarding the periodic classification were overcome by Soddy, who applied the term "isotope" to substances occupying the same place in the periodic table and which cannot be separated chemically, but whose atomic weights may differ slightly.

With regard to the study of X-rays themselves, no outstanding advances were made for some ten years after their discovery, when Barkla obtained evidence of the existence of "characteristic" radiations from experiments on secondary X-rays. The discovery led to the wave-theory of the X-rays, which was completely substantiated at later dates by the diffraction experiments of the Braggs, Moseley and Darwin. Barkla's characteristic rays are thus shown to be of the same nature as the rays yielding bright line spectra in the case of ordinary light. The diffraction experiments led to the employment of the X-rays for two classes of investigation—in the hands of Professor Bragg and his son, problems of crystal structure have been successfully attacked, while in the other direction the late Mr. Moseley has shown these phenomena to be a most powerful method of investigating the constitution of the elements. He showed that the critical property of an element was its atomic *number*, while its atomic weight was relatively of secondary importance. The important relationship between the frequency of the K or L series of characteristic rays and the atomic number of the element should be known as Moseley's law.

WAR-TIME ALLOTMENTS.

The *Journal of the Board of Agriculture* announces that during the third week of February land for over 7,000 new allotments was acquired or arranged for by twenty-five local authorities, acting on the advice of the Food Production Department, the acreage concerned being 499¾ acres. The average increase in the number of new allotments for the four preceding weeks laid out under the Cultivation of Lands Order by local authorities was at the rate of about 10,000 plots weekly. These figures are exclusive of the large number of new allotments provided by private arrangement.

Steps are being taken to secure land for cultivation by the workers at all munition factories. The idea is to utilise the produce of these allotments in munition canteens.

Schemes have been prepared to obviate waste of surplus produce raised by small cultivators. The essential part of these schemes, which, where necessary, will be modified to meet local requirements, is the establishment in each village of a collecting depot, to which all surpluses, however small, may be brought for packing and despatching to market. With the view of encouraging this desirable effort in co-operation, the Ministry of Food has undertaken to treat the potato crop raised by small cultivators in 1918 on an equal footing with the crops of potatoes grown on farms. Provided the small cultivators in each district combine, so that the produce can be bulked and transport saved, the State will purchase all the surplus main crop potatoes grown on holdings, no matter how slight. The experiment will be watched with much interest.

GENERAL NOTES.

Trinidad Oil Resources.—The Under-Secretary of State for the Colonies, Mr. Hewins, has informed the House of Commons that there are fourteen companies at present engaged in the oil industry in Trinidad. Three hundred and sixty-five wells have been sunk, and during November, 1917, to which the latest returns refer, 146 wells were actually being worked, and the quantity of crude oil produced amounted to upwards of 4,500,000 imperial gallons. Applications for further oil licences and leases receive the careful consideration of the Colonial Office and of the Trinidad Government, but by far the larger part of the presumed oilfield is already under licence or lease.

Treasury Notes.—Replying to a question in the House of Commons recently, the Chancellor of the Exchequer said the amount of currency notes outstanding at February 27th, 1918, was £218,409,536, against which £26,500,000 was held in gold. The total amount of Bank of England notes outstanding on July 29th, 1914, was £35,121,405, of which £29,706,350 were in circulation, and £35,415,055 in the reserve. There were no accurate statistics of the amount of gold in circulation at the outbreak of war, but the amount in the hands of the banks and the public, exclusive of gold held by banks of issue against their note issues, was estimated at about £120,000,000.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

APRIL 24.—SIR MAJOR ROBERT ARMSTRONG JONES, R.A.M.C., M.D., F.R.C.S., "Mental Effects of the War and their Lessons in Social and Medical Reconstruction." The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., will preside.

MAY 1.—GEORGE MARTINEAU, C.B., "Sugar from several Points of View." The RIGHT HON. LORD BALFOUR OF BURLEIGH, K.T., G.C.M.G., G.C.V.O., will preside.

MAY 8.—JOHN B. FARMER, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m. :—

MAY 30.—HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

COLONIAL SECTION.

Tuesday afternoon, at 4.30 p.m. :—

APRIL 30.—SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana." SIR EVERARD IM THURN, K.C.M.G., C.B., will preside.

CANTOR LECTURE.

Monday afternoon, at 4.30 p.m. :—

J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, "Military Explosives of To-day."

Syllabus.

LECTURE III.—APRIL 22.—High explosives used for shell filling—Methods of detonation—Initiators of detonation — Tests applied to explosives — Miscellaneous.

SPECIAL LECTURES.

A special course of three lectures on "The Freedom of the Sea" will be delivered on Thursdays, May 2nd, 9th, and 16th, at 4.30 p.m.

LECTURE I.—By GERARD FIENNES. Chairman, J. L. GARVIN.

Syllabus.

THE FREEDOM OF THE SEAS.

Freedom without Law. — The first maritime peoples—The Viking Age—Edward III. and the sovereignty of the seas—The Hansa—The Italian Republics in the Mediterranean.

Law without Freedom.—The discovery of the passage round the Cape of Good Hope and of America—The Bull of Alexander VI.—Henry VII.'s licence to the Cabots—Elizabeth's views—The English and Dutch—The war of Jenkins's Ear—The mercantile system—Berlin decrees—Orders in Council.

Law and Freedom.—Britain's work—Freedom "made in Germany."

LECTURE II. — By SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., Chief Justice of Hong-Kong, 1905–12. Chairman, LORD SANDERSON, G.C.B., K.C.M.G.

Syllabus.

THE FREEDOM OF THE SEA IN WAR.

The breakdown of International Law due to unpractical theories—Effect of war on the Freedom of the Seas—Limitations of neutral commerce with the enemy—Rule of 1756—All interference with neutrals based on prevention of assistance to the enemy—"Free ships, free goods": the neutral doctrine essential to maintain the enemy's fleet—Foundation of a spurious Freedom of the Sea claimed by enemies and neutrals: consistent opposition to the doctrine by England—The armed neutralities—American War of Independence—Bonaparte's theories—Immunity of private property at sea—Declaration of Paris—Maintenance of English principles of belligerency essential to an effective League of Nations.

LECTURE III.—By JOHN LEYLAND. Chairman, The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S.

Syllabus.

THE GERMAN "FREEDOM OF THE SEAS."

Britain the great upholder of the Freedom of the Seas—The meaning of the term—How it was regarded by Grotius—How we came to be denounced as the "tyrants of the sea"—The attitude and policy of Napoleon—His claim to be the liberator from tyranny—The modern German claim a protest against British sea-power—An analysis of the claim—Its real meaning—The view held and expressed in the United States—The agreements and understandings with Prussia—President Wilson's declaration—How it is in conflict with the German claim—The need of a right understanding of the subject.

COBB LECTURES.

PROFESSOR HENRY R. PROCTER, D.Sc., F.I.C., Leather Industries Department, The University, Leeds, "Recent Developments of Leather Chemistry." Two Lectures.

May 13, 14. At 4.30 p.m.

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JOURNAL OF THE ROYAL SOCIETY OF ARTS

CONTENTS.

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LONDON:
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REGISTERED AS A NEWSPAPER.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 29 ... Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Mr. J. C. Newsham, "The Future Position of Women in Agriculture."

TUESDAY, APRIL 30...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Colonial Section.) Sir Walter Egerton, "British Guiana."

Royal Institution, Albemarle-street, W., 3 p.m. Professor Arthur Keith, "Cave-Hunters." (Lecture III.)

WEDNESDAY, MAY 1...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. G. Martineau, "Sugar from Several Points of View."

Geological Society, Burlington House, W., 5.30 p.m.

Royal Institution, Albemarle-street, W., 5 p.m. Annual Meeting.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 5 p.m. 1. Mr. O. D. Roberts, "Factors affecting the Composition of Plant Ashes, with Special Reference to Tobacco." 2. Messrs. H. E. Annett and H. Singh, "The Effect of Codeine in hindering the Precipitation of Morphine by Ammonia from a Solution of its Lime Compound." 3. Messrs. J. L. Baker and H. F. E. Hulton, "Analysis of 'Cocoa Teas.'"

THURSDAY, MAY 2...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Special Lecture.) Mr. G. Fiennes, "The Freedom of the Sea."

Aëronautical Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. 1. Mr. G. M. Thomson, "On a new Fresh-water Shrimp (*Caridina*) from Fiji." 2. Dr. Marie Stopes, '*Bennettites Scottii*, sp. nov., a European Petrifaction with Foliage." 3. Dr. Marie Stopes, "A Survey of the Biological Aspect of the Constitution of Coal."

Chemical Society, Burlington House, W., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Isambard Owen, "Rheims Cathedral." (Lecture II.)

Metals, Institute of, at the Institution of Civil Engineers, Great George-street, S.W., 10.30 a.m. (Annual Meeting.) 1. Presidential Address by Mr. C. Eugène Schneider. 2. Selections from following papers: Report of the Blast Furnace Committee, "Practical Points affecting Yield and Efficiency of Blast Furnaces." Mr. G. D. Cochrane, "Importance of Coke Hardness." Dr. F. H. Hatch, "Economic Value of the Jurassic Iron Ores of Great Britain." Mr. T. C. Hutchinson, "Fuel Economy in Blast Furnaces." Mr. A. Lennox Leigh, "Economy in Gas Cleaning." Mr. Kenneth Chance, "Potash Recovery from Blast Furnaces." Mr. E. H. Lewis, "Manufacture of Portland Cement from Blast Furnace Slag." Dr. J. E. Stead, "Blast Furnace Bears." Dr. A. MacWilliam, "Technical Aspects of the Establishment of the Heavy Steel Industry in India, with Results of Some Researches connected therewith." Mr. B. Talbot, "Production of Sound Steel by lateral compression of the top portion of the Ingot." Mr. J. N. Kilby, "Steel Ingot Defects." Dr. J. E. Stead, "Notes on Inclusions in Steel and Ferrite lines." Mr. A. McCance, "Non-metallic Inclusions in Steel." Dr. W. Rosenhain and Mr. D. Hanson, "A Cause of Brittleness in Mild Steel Boiler Plates." Mr. E. F. Law, "Effect of Mass on Heat Treatment." Mr. J. H. Whiteley, "Effect of Cold Work on the Divorce of Pearlite." Mr. J. A. Van Den Broek, "Effect of Cold Working on the Elastic Properties of Steel." Dr. J. E. Stead, "Iron, Carbon and Phosphorus." Colonel N. Belaiew, "Damascene Steel." Dr. J. N Friend, "Protection of Iron with Paint against atmospheric Corrosion." Messrs. W. R. Schoeller and A. R. Powell, "Determination of Cobalt and Nickel in Cobalt Steel."

5 p.m. Annual May Lecture. The Hon. Sir Charles A. Parsons, "The Formation of Diamonds."

FRIDAY, MAY 3...Sociological Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m.

Royal Institution, Albemarle-street, W. 5.30 p.m. Sir George Greenhill, "The Spinning Top in Harness."

Metals, Institute of, at the Institution of Civil Engineers, Great George-street, S.W., 10 a.m. (Annual Meeting continued.)

Philological Society, University College, W.C., 8 p.m. Anniversary Meeting. Mr. H. Palmer, "The Ergonics of Japanese."

SATURDAY, MAY 4...Royal Institution, Albemarle-street, W., 3 p.m. Professor H. F. Newall, "Modern Investigation of the Sun's Surface." (Lecture II.)

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FRIDAY, APRIL 26, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

TUESDAY, APRIL 30th, at 4.30 p.m. (Colonial Section.) SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana." SIR EVERARD IM THURN, K.C.M.G., C.B., will preside.

WEDNESDAY, MAY 1st, at 4.30 p.m. (Ordinary Meeting.) A paper by GEORGE MARTINEAU, C.B., on "Sugar from Several Points of View," will be read by EDWARD R. DAVSON, President of the Associated West Indian Chambers of Commerce. The RIGHT HON. LORD BALFOUR OF BURLEIGH, K.T., G.C.M.G., G.C.V.O., will preside.

THURSDAY, MAY 2nd, at 4.30 p.m. (Special Course.) GERALD FIENNES, "The Freedom of the Seas." J. L. GARVIN will preside. (Lecture I.)

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On Monday afternoon, April 22nd, Mr. J. YOUNG, O.B.E., A.R.C.S., F.C.S., Chief Instructor in Science, Royal Military Academy, Woolwich, delivered the third and final lecture of his course on "Military Explosives of To-day."

On the motion of the CHAIRMAN (Major-General Sir Desmond D. T. O'Callaghan, R.A., K.C.V.O.), a vote of thanks was accorded to Mr. Young for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

EIGHTEENTH ORDINARY MEETING.

Wednesday afternoon, April 24th; The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., in the chair. A paper on "Mental Effects of the War and their Lessons in Social and Medical Reconstruction" was read by MAJOR SIR ROBERT ARMSTRONG-JONES, M.D., F.R.C.S., R.A.M.C.

The paper and discussion will be published in a subsequent number of the *Journal.*

EXAMINATIONS.

The entries for the Society's Examinations this year number 30,720. Of these, 10,828 were received for the examinations held in March, and 19,892 for those commencing on May 6th.

These entries show an increase of 4,814 over those of 1917, when 25,906 entries were received.

In addition to the above, entries have been received from interned prisoners of war at Chateau d'Oex and Mürren, Switzerland, and from the internment camp at Groningen, in Holland.

PROCEEDINGS OF THE SOCIETY.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 20th, 1918; SIR HENRY TRUEMAN WOOD, M.A., Member of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Heine, William M., Connecticut, U.S.A.
Malcolm, George William, London.
Stobie, Victor, Gosforth.
Strachan, Robert Price, Bristol.
Weir, John Cunningham, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Anstruther, George Elliot, London.
Crabb, Thomas, M.I.Mar.E., A.M.I.Mech.E., Bengal, India.
Hepburn, Andrew, Horley.
Letcher, William Whitburn, London.
Mannell, John, London.
Mitchell, Ernest J., London.
Murray, Alexander Robertson, Calcutta.
Pardoe-Thomas, Bertie, J.P., Newport, Monmouth.
Pocock, George, London.
Poupart, John, Walton-on-Thames.
Powles, George Everett, Leeds.

Rama, Varma Raja, His Highness, F.R.Hist.S., Malabar, S. India.

Robertson, Walter Henry Antonio, Bedford.

Stewart, John, London.

Tonkin, Wilfrid Wiseman, Lic.R.I.B.A., Potchefstroom, South Africa.

Ullyott, E., Leeds.

Walter, Francis Henry, Rio de Janeiro, Brazil.

The paper read was—

THE FOOD SITUATION IN GERMANY.

By Percy Shuttlewood.

The food situation in Germany is so vital in its bearing on the war that a dispassionate investigation of the existing conditions is of interest. A survey of available statements and statistics leads to a general conclusion that the immediate situation in the countries of the Central Powers is grave enough to be termed critical. It may be laid down as a general proposition that Germany is able normally to produce from her own resources a bare sufficiency of food to keep her people alive. It is abundantly clear that a bare sufficiency is inadequate to maintain a nation's highest efficiency. The cumulative force of the food shortage, the lack of variety of food, the difficulties of transport, and the inequalities of distribution are exercising a continuous drag on the power and will of the German people to carry on.

After three years' experience of a rationing system and one year of an official Food Controller, Germany still finds it impossible to come within measurable distance of solving her problem of distribution.

The results of the British blockade can best be judged from the effect which the blockade has produced on the larger industrial and commercial towns in Germany. Every country has certain agricultural districts which are more or less self-supporting, but by cutting off supplies from outside it is possible to reduce a country to the position of having to fall back upon its own supplies. As far back as November 26th, 1917, mass meetings, summoned by the Federation of Trade Unions, were held in seven large halls in Berlin to bring pressure to bear on the authorities with a view of improving the food ration of the Berlin working-classes. A resolution was passed at all these meetings demanding more energetic opposition to illicit trading, a uniform supply for the whole economic area of Greater Berlin, and an increase of the potato ration to 10 lb. per head per week. In spite of all their resolutions, however, it appears that the rations of meat, bread, potatoes, and sugar remained unchanged for the area of Greater Berlin in December and January. Although the potato ration was fixed at 7 lb. per week, only a 6 lb. ration was distributed during the week beginning December 31st.

The fats ration was reduced in December to 2·5 oz. A ration of one egg per week was fixed for the period December 17th to 31st.

Apparently the small rural communes round Berlin are as hard hit as any place in Germany.

Berlin is not the only town in Germany which is feeling the pinch of the British blockade, as evidenced by the fact that in 1917, 40,000 children were sent from Hamburg schools into the country in order to recuperate. According to a merchant who has recently left Hamburg, after a long stay in that town, one could obtain almost anything there by buying secretly and paying fabulous prices. As an instance he cites the case of a ham weighing 15 lb. purchased for £47 10*s*.

It is obvious, however, that everybody in Hamburg cannot afford these prices. Eggs, fats, and butter are extremely scarce, and the soup kitchens are getting very bad. People in Hamburg are very weak, especially the women and children, who are feeling it badly. Naturally there is discontent when people see that the rich are able to obtain food at prices which are beyond the reach of the poorer classes, and it is stated that the people of Hamburg are frankly speaking of revolution after the war.

Illicit trading is gradually assuming dimensions which justify the fear that the whole public supply of food in Germany may be undermined. Private smuggling between consumer and producer is the natural reaction against the orders of the rationing system as operated in Germany. Little attention was paid to it at first, and as it developed it was opposed in an inadequate fashion because there was no definite procedure and too many extenuating circumstances were taken into account. The District Commissioner who could allow the city man who had rented a shoot to take butter and lard with him, could not proceed with energy against Sunday excursionists.

The municipal authorities were not displeased, in their turn, to see this increase in the supplies of their citizens. It is asserted that in the early spring of 1917 absolute distress was only avoided in Frankfort by openly dealing in illicit trading, which brought potatoes previously hidden from the authorities into Frankfort by the hundred-

weight. This illicit trading, moreover, is not by any means confined to well-to-do circles, but everyone uses his connection with the war to increase his meagre ration from one source or another.

Frankfort is the town where the egg ration works out at one egg per head for four weeks. The fat ration is 1·7 oz. per week; and the meat ration 7 oz. per week.

Hanover, however, promises to be even worse off. The weekly ration of butter has been steadily decreasing. In February, 1918, the butter consignments were so small that the magistracy announced that, in place of butter, 2·1 oz. of the best edible fat, a very imperfect substitute, would be given.

The proceedings of the Chamber of Agriculture in Hanover provided a fairly good insight into the local conditions. Apparently 1917 has been a bad year for agriculture. The drought, which lasted until June, played havoc with the oat crops, and the autumn-sown crops were hardly of medium standard. Lack of manure, shortage of labour, and insufficiently nourished teams, have all been unfavourable to the harvests. Encroachments made on cattle stocks have given serious cause for anxiety as to the future of breeding. Pig stocks have been ruined, the number of pigs having decreased from 25,000,000 to 5,000,000 since the beginning of the war.

Of course, conditions such as these are bound to affect the large towns. There is an epidemic of "hunger typhus" in Hanover as well as in South Germany.

In Bentheim, on the Dutch frontier, they have one egg weekly and 2·975 oz. of butcher's meat. Coffee, tea, cocoa, and rice are unobtainable, except what the smugglers bring and sell at incredible prices. One half-pound of tea costs £1 5*s*. A protest was recently forwarded to the Ministry of Food by the Hirsch-Duncker, the Union of Engineers and Metal Workers. The metal workers are engaged in munition-making, and are visibly collapsing through physical strain and inadequate food. Groats, barley, peas, fat, etc., are supplied to them in very small quantities, and sometimes not at all. The only thing that the workers have to depend on is potatoes. The ration of 7 lb. per week is quite inadequate, and their future capacity is seriously threatened.

In every part of Germany the authorities are confronted with the same problem of illicit trading, and this is one of the main grievances under which the German workman is labouring to-day. He is tired of the war; he is expecting a certain amount of food and he does not get it; he sees others who appear to have no difficulty in obtaining in some mysterious way commodities which he has to go without. It does not require a very great knowledge of psychology to enable one to form a fairly accurate idea of the German working-man's mind under such conditions.

A Dutch traveller, writing to friends abroad, says: "I saw, during my holidays, some German girls, aged sixteen years, who came to us to be fed. They had gruesomely thin legs and faces, wasted to skin and bone. They were so weak that they could not retain any kind of food. The people showed us a letter from a German boy about ten years of age, who, four weeks after he had returned to Germany, wrote: 'The 12 lb. I gained I have already lost—quick, wasn't it?'

"I do not understand how they copy in the papers such a report as this: 'Even in the fourth year of the war the food provisioning gives us no anxiety.'"

The Germans are reading such news, and yet they feel they are starving.

The following is an extract from a letter which was written in Bremen: "We have not had any potatoes for six weeks, and we only get 5 lb. of bread and 1 lb. meat per week, and every fortnight or three weeks 3·5 oz. vermicelli or barley, not enough to live upon, and too much to starve to death. Without our supply of milk we should have all died." The writer also complains of the unduly hard lot of the working-classes as compared with rich persons.

The people are suffering, but they are buoyed up by hopes and promises from the German authorities. The majority of the people want peace, but they dare not express their opinions openly for fear of the consequences.

The writer of the letter to which I refer does not think that there is the least fear of any revolution, as the masses are crushed under the heel of the military authorities.

A writer from Spain says the Germans have brought food rationing to a "scientific fine art," and it is marvellous what they have been able to do, making one thing replace another, and doling things out in such quantities as are just enough to keep the people from starving to death. When people are prepared to pay over £45 for a single ham, one can understand that hosts of opportunities will spring up in order to do business under such conditions. For weeks the authorities have been bullying the wretched municipalities without taking any steps to

remove the cause of the prevailing abuses. Recently the municipal authorities purchased a number of truck-loads of white cabbage at a price above the maximum 11*s.* per cwt. The firm of Krupp pay 17*s.* per cwt. Nothing is known of any action against Krupp.

The Ministry of War is endeavouring to profit by such transactions. The War Department was offered ham and sausages at 14*s.* per lb., which were bought up at once.

At a meeting of the Imperial Fruit and Vegetable Offices, attended by representatives of the Berlin food committees, the representatives actually stated that the observance of maximum prices at present could not be thought of, and stopped all debate on the point. On one hand the legal authorities are announcing their intention of prosecuting all offenders against maximum prices legislation, and, on the other hand, the Imperial authorities are deciding that for the time being, at any rate, maximum prices may be exceeded.

A German newspaper's comment is: "The nation will certainly conclude that there is no serious desire to improve matters. The people ask for bread and are being played with."

It is true that the authorities are taking timid steps towards checking the illegalities of industrial firms. The War Food Bureau recently discussed the situation with the managers of industrial undertakings, and issued a warning against publicly controlled foodstuffs being obtained through illicit trade. The defiance of regulations by private traders goes on unchecked. Pigs have been slaughtered at night without licence, and the meat sold, without inspection for trichina, at 5 marks (5*s.*) per lb., the maximum price being about 1·80 marks (1*s.* 9½*d.*) per lb. Apparently a buyer for the municipality of Allenstein, after giving up his butcher's business, went on for about twenty weeks with secret slaughterings of altogether about forty to fifty bullocks and ten to fifteen calves and sheep.

Pigs, calves, and sheep have been bought up without licences, secretly slaughtered, and resold to hotels. According to the *Münchener Post*, January 25th, 1918, the Munich railway station for Berlin was watched by detectives, and lately two suspiciously heavy boxes were opened and found to contain quantities of food and an invoice.

Butter was priced at 13 marks (13*s.*) per lb., and a ham for 75 marks (£3 15*s.*) The ham, in comparison with the other hams, appears to have been a bargain. A restaurant near the station has been enticing farmers to bring lard, butter, etc., into town by offering them up to 15 marks (15*s.*) per lb.

Munich is not, however, the only place where the station is watched. On any morning one can see crowds waiting in the cold and in the fog on the suburban railway platform of a Berlin station for the train to start. Long rows of hungry creatures are there—men, women, and children—all with baskets and sacks in their hands. Their baskets and sacks are laden with potatoes when they return twelve hours later, but the potatoes are confiscated by the police almost before they get out of the train.

A traveller in Holland who has recently left Germany, describes a scene at a station in Western Germany. A crowd of people who had been buying vegetables from local farmers found that the train which was to take them home was already full up. They smashed the carriage windows and almost wrecked the train in their endeavour to get seats.

Apparently the railway conditions in Germany are getting worse and worse. Soldiers who come from the front on leave state that the conditions in Germany are worse than in the occupied parts of France and Belgium. A prisoner of war who escaped from Germany last December, after having been more than three years in various camps, states: "At first they seemed to have plenty of food, and to be very confident about things, now they are very downhearted and they do not seem to care very much which way the war goes as long as it comes to an end soon. At one time they used to read the papers a lot, but now they do not seem to worry about it. They would say that the war was all for the Kaiser's pocket and the poor man would get nothing from it."

Bread often has bits of wood in it, and the British prisoners used to give their bread to the Russian prisoners who were in a barrack close by. Their civilian sentry used to say it was worse for the women and children as they had no milk.

The German authorities are powerless to suppress illegal trade, and consequently, in spite of careful calculations, there is not enough food left to distribute according to the scale of distribution. The Food Controller reckons on a certain supply and arranges a distribution; but meanwhile transactions are going on concerning which he knows little or nothing, the net result being that the supply does not come up to his expectations, and the distribution suffers accordingly. The people, therefore, do

not get what they have been promised; they have, moreover, to pay a price above that which has been fixed by Government. Their grievance is a perfectly legitimate one, and nothing saps the patriotism of a nation more than a series of justified grievances. Probably it is this grievance which has contributed to war weariness on the part of the masses in Germany more than anything else. It is foolish, however, to conclude hastily that because the German people are hungry and war weary therefore they are ready to revolt.

An announcement appeared on October 9th, 1917, that the War Food Ministry had been reorganised on a new basis. This Ministry will consist of a Minister, two under secretaries, and nine other members. The Minister will conduct the business and will represent the Ministry outside, and will be responsible for the fulfilment of the duties entrusted to it. He will decide important questions only after consultation with the advisory committee, at whose meetings he will preside.

The system of rationing by card appears to have been very complicated, and, in order to guard against forgeries, the Food Supply Bureau has always used paper with a watermark. The control starts with the paper, which is supplied by the factory direct to the Food Supply Bureau. The paper is manufactured and counted under official supervision and stored in the cellars of the Food Supply Bureau. It stands to reason that precautionary measures have been taken to prevent fraud. The sheets of paper are counted off as wanted and delivered to the printers, who print under constant supervision. During the dinner-hour the machines are put out of action and sealed. Nine printing establishments are employed with 160 honorary supervisors.

The cards, when printed, are packed in parcels, then sealed, and are sent to the distribution offices in military motor-lorries under the most careful control. The parcels are locked up in schools in separate boxes, where they remain only one, or at most two, nights. Then they are sent to the commissions, still under guard, and are then put into the envelopes and delivered by school children. Also in the schools precautions have been taken against fraud and theft. When the periods of the cards have expired the distribution offices have to make up their accounts. Any surplus, never very extensive, is returned to the Food Supply Bureau. Formerly the surplus was burnt; now, on account of the scarcity of paper, the waste-paper is pulped under strict supervision. The Food Supply Bureau gives the assurance, relying on its accurate book-keeping, that the number of cards distributed now corresponds with the number of the census. The enormous business transaction involved is illustrated by the fact that for bread cards alone 50,000 to 60,000 sheets of paper are used every fortnight. And if one remembers that 130 different cards are in question, and that every card has to be booked, a good idea is gained of the daily amount of work.

The most difficult part is the distribution of cards to men on leave at the chief railway station. Five thousand men on leave have to be supplied daily. The different periods of leave, which make it necessary for cards of the old and new distribution periods to be issued at the same time, and the necessity for taking into account the meat days, combine to render the issue very difficult. The cards are now handed out in envelopes; for seven days' leave (five meat days) these contain vouchers for 2,000 grammes of bread and flour, ten meat vouchers (each one valid for a tenth of a current weekly supply), fourteen potato vouchers, seven milk vouchers, seven sugar vouchers, one fat, one cheese, and one groceries voucher, and an egg card.

As soon as an order is issued, three-fourths of the population seek how they may evade it. They have lost faith in official promises, and the fear of starvation has them in its grip.

It is stated that in the country all possible provisions can be obtained if one has other commodities—*e.g.* sugar, rice, soap, petroleum, etc., to exchange. The shopkeepers in the towns are also good hands at this system. Though they may have nothing on view in the shop there is always something in the background which they will exchange for other goods on favourable terms.

A complicated and special series of coloured cards has become necessary in order to control milk distribution. Brown cards are used for skim milk issued to women and girls, black cards for skim milk to men and boys, and red cards for children's whole milk rations. There appear to be other sub-divisions to include invalids and old persons.

Further complications have been introduced in certain districts: for example, in Hanover milk salesmen have been directed to favour families with children over six years of age, and for this purpose may issue *special* cards or even supply milk on ordinary *food* cards.

The constant variation in supplies of any foodstuff constitutes another difficulty, necessitating continual changes in orders. For instance, in Hamburg recently it was ordered that 1 lb. of white cabbage should be supplied on each card contrary to the procedure of the previous week, when cabbage was supplied on several household cards only.

The problem of arranging for persons who take their meals in restaurants has been the occasion of much controversy. In Austria special restaurants have been introduced covering the whole meal. The official meal check must be handed to the restaurant proprietor, and persons applying for meal checks must have a written declaration that they regularly take their meals away from home.

It is not clear how far such persons become entitled to any ordinary food cards, but the system seems to be open to abuse. The usual method in Germany is for restaurant diners to produce their ordinary cards at a meal and for coupons to be detached covering the rationed dishes. There are always a number of dishes not requiring cards. It is also possible to buy books of restaurant coupons, ordinary food tickets being surrendered in return—*e.g.* one bread ticket for thirty restaurant bread coupons. There has been much evasion of the regulations in restaurants, and a great tendency for unrationed foods to be supplied only at exorbitant prices.

As regards mass feeding in public kitchens, the card system seems to have partially broken down. In 276 establishments, of which sixty-nine were public war kitchens, the demand for surrender of food tickets has been abandoned. These establishments are almost entirely in the smaller communes.

In the other towns surrender of tickets is made a condition in order not to interfere with the equitable distribution of supplies over the whole population.

It is of interest to note that a system of supplying separate courses has been generally given up in favour of the one-course meal.

Towards the end of August, 1917, in Altona and Hamburg it was found advisable to modify the organisation of all kitchens in order to make the food more nourishing and varied. A report which reads like an official order, alludes to Imperial food cards, the use of which in connection with war kitchens appears to require a considerable amount of adjustment:—

"From August 20th only such people can order food from the Altona war kitchens as have in the preceding week got for themselves vouchers entitling them to an allotment of food on presentation, and involving cancellation of a corresponding amount on the imperial meat, potato, and food cards.

"If a kilo of food per day is ordered for the duration of a week, half of the weekly amount of potatoes, half of the ration in farinaceous foods, and six-tenths of the weekly meat ration must be cancelled. Those who fetch the food may not receive more than 1 kilo per head daily. Only those who consume the food in the kitchen may eat 1½ to 2 kilos there daily. When these order 1½ kilo of food for the week, five-eighths of their potato ration will be cancelled, besides the above-mentioned amounts of farinaceous food and meat. When they order 2 kilos of war kitchen food daily for the week, six-eighths of the weekly potato supply will be cancelled, besides the above-mentioned amounts of meat and food. The vouchers are available only for the kitchen marked on them and in the week for which they are issued.

"Inhabitants of Altona who wish to order food from a war kitchen must obtain their vouchers at their proper bread commission, and must then exchange them at the Hamburg kitchen from which they want to order the food for the cards there current."

An official inquiry took place as to the extent to which the various people's and middle-class kitchens make the amount of food supplied by them dependent on the surrender of meat, potato, fat, and other food tickets. Replies were received from one hundred municipalities, and these show great difference both as to the manner and the extent of deductions made.

In most towns tickets must be surrendered for meat and potatoes, but only a minority demand fat, pulse, flour, or other food tickets. In a few towns the people's kitchens do not as yet require tickets; some other towns require them only for potatoes.

As to meat tickets, there is evidence of a general desire to meet the wishes of the participants as far as possible, and to leave them a larger or smaller portion of the ticket at disposal for use elsewhere. The extent to which surrender of the tickets is required depends in the various people's kitchens on the greater or less frequency with which meat dishes are provided. Frequently the rule obtains that the surrender of only half the meat tickets is required. The majority of towns have introduced day tickets, but others have weekly and monthly tickets, and a few even demand the meat and other tickets for three months in advance.

With regard to the U-boat campaign, the secret history of this venture is interesting. Early in 1916 ten financial and industrial experts were questioned as to the advisability of Germany pursuing an unrestricted submarine campaign. They all agreed that six months of ruthless U-boat warfare would compel England to sue for peace. Had these men foreseen for a moment that the war would go on in spite of all, it is hard to conceive that they would have advocated a policy so suicidal to their own interests.

"Die Hilfe" says the authorities were deceived on very substantial points regarding its effects. It is not much consolation to a hungry man to be told that his countrymen have just succeeded in destroying vast quantities of food.

Herr Segitz, at the sitting of the Bavarian Diet in January of this year, referred to the U-boat campaign. He said: "We are confronted with world famine, yet we are rejoicing every day when ships with provisions are sunk because we hope it will force England to surrender. But after the war ships will be lacking to bring us corn."

It is perfectly true that efficiency rather than humanity is the German ideal. Her food organisation is certainly nothing to admire. She still has her queues, and is not likely to get rid of them.

The press of this country and speakers generally often draw comparisons of the relative English and German rations.

In no part of Germany is the full ration to be obtained with any degree of regularity.

The statistics to which so much importance is attached in this country are not accepted by the German Food Controller himself, who has stated:—

"Our potato harvests can be designated as satisfactory and in some parts good. Since the statistics appear to have proved misleading a revision is ordered to take place immediately."

Not long ago the town council of Neukoln (Greater Berlin) submitted a memorial to the President of the War Food Bureau. It was rigidly repressed by the authorities. This document accuses those who handle the country's food of partiality, and demands drastic reforms which will secure uniform distribution.

Recently captured documents included a letter from a certain Government official, which showed clearly that it is the middle and lower classes in Germany that are suffering severely. The mass of Government officials, bureaucrats, influential junkers—in fact, all who hold office in the Government itself—have little difficulty in procuring supplies. It is an ugly picture of Prussian bureaucracy at its worst.

Last year in Prussia alone there were over 40,000 prosecutions for food hoarding and profiteering. In some towns the bread cards had to be called in, as so many people were forging them.

A British officer, recently returned from Germany, states that during the last two years there has been a very marked difference in the appearance of the inhabitants. The men are thinner; the women and children are white and pinched. Last winter the death-rate in certain towns was exceptionally high. Epidemics among the very young have been common, generally of an intestinal nature due to the use of substitute food.

German soldiers in hospital state that deaths from disease have increased enormously in the army. With regard to food issued to the army, evidence all points to the fact that both in quantity and in quality the rations are rapidly deteriorating. British doctors who examine prisoners of war as they are brought in agree that the physique of the German soldier is not what it used to be. They are unanimous in tracing the cause to the lack of proper nourishment.

The German Food Controller has stated in the Prussian House of Deputies that the fourth year of war would impose many restrictions. Bread and potatoes, he said, will form the mainstay of the food supplies. Amid a mighty sounding of trumpets the German professors devised a process for extracting nitrogen from the air. As a makeshift this has its uses, but only as a makeshift. The nutritive values of the foods thus produced are greatly inferior, on the showing of their own scientists, to pre-war foods. They grind acorns and call the result coffee. Sawdust is used as a flour stretcher. Von Waldow's rationing system is a failure. The Prussian system breaks down, as Von Waldow ruefully confesses, when applied to producers, profiteers, and the distributing agencies. The farmers make dishonest returns. The profiteering middlemen pile up their profits and snap their fingers at the State.

The German authorities are powerless to control the distributors. They are powerless to organise the transport of food. The military demands on transport take precedence. The lack of grease and the colossal deterioration of rolling-stock of the Empire are vital factors.

Little wonder Von Waldow's rationing system has proved a failure. The people asked for bread and he gave them coupons. They stood long hours in queues and came away empty-handed. He failed because there was too little food and he was powerless to control the supplies.

Hans Vorst has discussed the dangers from a German point of view of overrating the economic consequences of peace with Russia, and points out that at all times Russian exports have only been possible to the detriment of the masses. Owing to the shortage of agricultural labour both the area under cultivation and the yield has during the period of the war decreased year by year. At present it is doubtful if the crops, even with efficient organisation, are sufficient to meet the needs of the Russian people.

It is possible that there may exist some surplus holdings or land held by the peasants themselves. Neither the Imperial nor the Provincial Governments of Russia, however, succeeded in raising the hidden treasures. One may therefore doubt their magnitude. When the Kerensky Government, in September, 1917, doubled the maximum prices the peasants were still reluctant to sell. If Hans Vorst is right, it is patent that the Central Powers have little to hope from Russia. Vorst bases his arguments on solid facts.

The fabric built up by the Prussian system has not yet been destroyed. The will to victory is impaired. It is maintained by coercion and lying promises, by threats, by dramatic achievements. For the rulers of the German Empire everything is at stake. They will leave no stone unturned to prevent the Empire from collapsing under the pressure of hunger. Though red ruin and disease are prophesied for the people at large, those who will suffer least are those who still guide the helm of State. Although Germany's condition is critical it would be premature, and in the highest degree imprudent, to assume her early collapse.

DISCUSSION.

The Chairman (Sir Henry Trueman Wood), in opening the discussion, said he believed an eminent philosopher once divided mankind into two classes—the people who ate too much and the people who did not get enough to eat. There was no doubt that in the past a very large number of Germans belonged to the first class, but the great majority of them had now been brought into the second class. It was satisfactory to have confirmed in the paper the information given by the various correspondents who had sent letters to the *Times* and other papers depicting the condition of Germany. To his mind it was degrading that the people of this country should be compelled to gloat over the misfortunes of those who, after all, were their fellow-creatures, but that was not their fault; the Germans had brought it upon themselves by their insensate plunge into war. The author had avoided drawing any comparisons between the food situation in this country and the situation in Germany, but there were several very useful lessons that might be obtained by such a comparison. The very moderate restrictions that the people of this country were now having to submit to were absolutely nothing compared with those which the Germans had been enduring for certainly three years; but it must be remembered that the time might very likely come when we should have to support hardships a great deal more severe than the present ones, and we must be prepared to bear them when that time came. A question that must arise in the mind of everyone was, What was to be the ultimate result of the starvation of Germany? Mr. Gerard, in the observations which he had recently published—observations notable for their shrewdness and their evident truth—stated that we could never look for any revolution in Germany, whatever might happen; and that was probably correct. If the people of England or America had been treated as the Germans were, there would very soon be revolutions, because those countries were democracies. It was the old story of a lot of loose twigs and a bundle of sticks—a democracy might be said to consist of people tied up into various bundles, who were in a position to say what they wanted and to see that they obtained it; whereas the German nation was composed of slaves who had no power whatever of making their will known; they were trodden down and had no organisation, and were not even allowed to express their opinions. The economic condition of Germany must have its effect, however, in the long run. People could not go on starving; they could not be infested by disease, as it was known the Germans were, and they could not be reduced to the lowest possible moral condition, so that crime was rampant in Berlin and in all the other German cities, and yet go on putting up a good fight. That might therefore be a cause for hope on the part of this country; there would not be a revolution in Germany, but there would be some sort of decay which eventually would bring about the defeat of the Germans. There was one point at the end of the paper which had rather puzzled him, where the author spoke of the production of nitrogen from the atmosphere. So far as his information went, the principal development of the manufacture of atmospheric nitrogen in Germany had been the application of steam-power to its production instead of water-power, a change only justified by the increased value of the product. The nitrates thus obtained were used in the production of explosives, as well as for fertilisers. He did not know that they had been utilised for

the manufacture of foodstuffs, and any information on this point would be interesting.*

ALDERMAN G. CLEMENT, speaking as a member of a food control committee, said that his committee had a great many difficulties to contend with. Several members felt that less corn should be used for brewing purposes, because everyone must recognise that the question of bread should come before beer. Undoubtedly a considerable quantity of good wholesome grain was being used at the present time for brewing, and those in authority might do well if they reduced the amount. The local food committees were told that from 30 to 35 lb. of potatoes should be used to every sack of flour in making bread, but difficulties had arisen in his district with regard to preparing the potatoes for that purpose. There was an abundant supply, but the bakers were disinclined to use the potatoes unless they were supplied with machinery for preparing them, and it was very difficult to obtain that machinery. One baker resident in his district had been promised a machine some time ago; it had been suggested that the Government should expedite the delivery of the machine, which would then be placed at the public baths, so that all the bakers in the neighbourhood could have potatoes prepared for them there. Unless some means of that kind were adopted it was very probable that the supplies of corn would not last out till the next harvest. There should also be some relaxation of the order issued by the Food Control Department to the effect that sugar for making jam could only be obtained by those who grew their own fruit. His committee thought that sugar for that purpose should be supplied to all who had got the fruit, whether they had grown it themselves, or purchased it, or had it given to them, provided they could satisfy the local food committee as to their intentions.

MR. W. E. OAKDEN wished to know whether the author could say what percentage of the total food supplies of Germany were produced in Germany before the war and at the present time, and also if he could give any idea of the date at which he considered the Allies' blockade was effective in preventing imports into Germany.

MR. W. J. BRAITHWAITE said that the German people loved the preparation of statistics, and the result was that the figures showing the number of prosecutions, the want of obedience to the law, and so forth, were accumulated in a way that was absolutely incredible to people in this country. He had twice had experience of official investigations in Germany, and on both occasions he had been very much surprised at the number of prosecutions, and the apparently horrible lawlessness of the population. He therefore wanted to introduce a note of caution on that subject. He did not believe the Germans were a lawless nation. They were very fond of multiplying statistics of lawlessness, and of telling each other if they broke a simple rule, and they were very fond of compiling statistics and publishing them. No matter what subject one was dealing with in regard to Germany, the result of those characteristics would be found; and he was certain that the figures given in the paper with regard to food had been produced by those characteristics.

MR. CHARLES HECHT said he had read in the papers that instructions were given in Hamburg, and other dockyard towns, with a view to enabling the population to use their food more economically, and he would like to know whether the author had any special information on that point.

MR. SHUTTLEWOOD, in replying to the discussion, said that the Chairman had mentioned the question of food substitutes, and in that connection he might mention an article written by Captain Ozanne with regard to the bread substitute used in Germany at the present time. The report stated that the bread substitute when cut emitted a peculiar smell which at first was almost fruity and not exactly disagreeable, but afterwards grew sharper, and finally became overpowering and offensive; and that the crumb of such bread was at first more or less yellow to yellow-brown in colour and then became sticky, and when cut or broken hung together in long, sticky, tough threads. That was some indication of the nature of the food substitutes that were used. With regard to the efficiency of the blockade, he could only say that the present situation in Germany had been brought about by the blockade, which had been gradually contributing to the present result ever since it was introduced. It was at the present moment undoubtedly effective. With regard to statistics, it was very difficult to give any that were really reliable. The official statistics issued by the German Government were not accepted by the German Food Controller; and in connection with the potato crops, the statistics which were sent to the German Food Controller were ignored by him, and he ordered a fresh revision, because he regarded the statistics of the German Government as entirely misleading. Any statistics he personally could give would be equally so, because they would be drawn from the same source. With regard to obtaining nitrogen from the atmosphere, as the Chairman had said, the idea was not of German origin, and he thought it had first been developed in this country. The

* In 1898 Sir William Crookes, in his Presidential Address to the British Association at Bristol, spoke of the utilisation of atmospheric nitrogen for the manufacture of fertilisers, as a possible method of replacing the exhausted supplies of natural nitrates. The practical solution of the problem may be attributed to the Norwegian, Professor Birkeland, who, with the assistance of the engineer, Herr Eyde (also a Norwegian), established a factory for the production of nitrates near Christiania in 1903. A full account of the process and of the factory afterwards set up at Notodden will be found in a paper read before the Society in 1909 by Herr Eyde.—H. T. W.

Germans, however, had developed it and applied it in many directions; but he was not a scientist, and could not speak with any authority on the subject.

The Chairman, in proposing a hearty vote of thanks to the author for his interesting paper, said it appeared from what the author had said that the Germans had been more successful in the synthetic production of dyes than in the synthetic production of food.

The resolution was carried unanimously, and the meeting terminated.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, March 14th, 1918, the Right Hon. J. Austen Chamberlain, M.P., in the chair. The paper read was "English Commerce with India, 1608–1658," by William Foster, C.I.E., Registrar and Superintendent of Records, India Office.

The text of the paper was printed in last week's *Journal*. The following is the discussion on the paper:—

DISCUSSION.

The Chairman (The Right Hon. J. Austen Chamberlain, M.P.) said that in tracing the origins of British trade with India the author had necessarily traced also the origins of the British connection with the Empire of India as it was known to-day, and it was very interesting to see the small beginnings from which so great a trade and so powerful an Empire had arisen. Trade had its romances no less than other aspects of our life that at first sight seemed more poetical, and if it was true to say that trade followed the flag, it was certainly also true to say that not infrequently the flag followed trade. The energetic, enterprising trader, responding to some personal desire for adventure or to some need for certain articles by his contemporaries, became, all unknowing, the discoverer and developer of new lands and the founder of new realms and empires. It was a far cry from the present time to the early days of the East India Company, but he thought that his late colleagues on the India Council who were present at the meeting must have felt—as he did—while listening to the paper, that after all the world sometimes came back on its old courses, and that events of long ago had a close analogy to the events of the present day. It was not merely that one found the indigo trade in the very early days with its difficulties, its partial failures, its gradual deterioration, just as had been seen again in more recent times when it fell from the great importance it once had, being superseded by chemical dyes, and dragging on a rather precarious existence, to assume, he hoped, in the future a fresh lease of good fortune and importance as science and skill were brought to bear more directly on its cultivation and preparation and the process of marketing it. It was not merely that one found old trades persisting, as, for example, cotton and indigo, but who would have expected to find a distressed Admiralty pressing the East India Company to supply saltpetre, just as the War Office or the Ministry of Munitions to-day asked the Secretary of State for India to do something in this or that direction for producing munitions of war? Then, again, there were complaints in the early days that the East India Company exported bullion. He had heard complaints of very much the same kind directed against the Secretary of State in Council in more recent times, and no doubt Mr. Currie would say that such complaints were heard in the City even to-day! So among many changes and vicissitudes the development of British trade with India had continued until at the present time it was one of the most important trades that this country possessed. He did not doubt that in one respect the war had been of advantage to India, because the Indian Government and Indian people had been stimulated to develop and make use of their own resources. They had been forced to look round and see how far they could provide for themselves articles or substitutes for articles which they had hitherto been content to buy from other countries. The inquiries undertaken in India for that purpose, and those conducted by Mr. Chadwick as to the markets available in European countries for Indian goods, promised to furnish great opportunities of development, of which he trusted India would take full advantage. Whatever might be the difficulties of adjusting British trade interests to those of India in any particular matter at any particular moment, in the long run those interests proved to be identical. There was plenty of room for both countries in friendly rivalry with each other or in assisting each other, and the prosperity of one could not be otherwise than advantageous to the other. He welcomed the prospects of a further development of trade between the two countries, and had listened with interest to the author's description of the first beginnings of that important trade.

Mr. Richard Burn, C.S.I., said that in Indian universities the study of Indian history and of Indian economics was now assuming a far greater importance than it had held in the past. Authorities in this country, from Lord Macaulay downwards, had frequently shown a good deal of contempt for Indian history, and even a more recent writer, Lord Morley, in his "Reflections," made rather depreciatory remarks about the subject, whilst Professor Rapson, a few years ago, almost apologised for producing a paper on Indian history. It must be admitted that Indian history as written hitherto had been largely a chronicle of kings and battles and petty squabbles, and it

was the need for revising such a chronicle, and showing more clearly the condition of the people and their economic state that made him welcome such a paper as the present one. During the last ten or fifteen years the study of economics from the Indian point of view had developed very considerably. In Bombay a School of Economics had been founded, and various university professors in other parts of India were opening *seminars* at which Indian students were being trained in research work. The author had stated that iron was exported to India, but had no chance there in competition with the cheaper products of India. To any one who knew India up to the last few years that statement was rather amusing, but since the foundation of the great factory by the Tata Brothers at Sakchi a return to those conditions might be possible, and he understood that the Indian Government had already commenced the manufacture of iron ships. Reference was made in the paper to the export of swords from India as being a trade of some importance. At the present time there were in India at least two very large collections of those weapons—at Jodhpur, and at Bikanir—which had never yet been examined by experts, but the Maharaja of Bikanir hoped to have them examined and classified, and to have an account published of the results. As a student of numismatics he had been much interested by the author's account of the method of remittances in cash to India from this country. The Spanish word *real* had been mentioned, and it was a curious fact that along the shores of the Persian Gulf the word "real" was still in common use as a generic term for foreign silver. The author stated that the most popular form of gold remittance was the English 20*s*. piece; in Hindustani at the present day the word for a sovereign was "guinea," which suggested that the guinea as well as the 20*s*. piece was exported.

MR. D. T. CHADWICK, I.C.S., said he hoped the author would continue his interesting examinations of the old records, and, in addition to noting the quantity and nature of the goods which came from India, would see if any light could be shed on the quality of those goods. One so frequently heard of deterioration, that any information on the grade of goods in olden days was of direct interest to all those in any way connected with economic or trade development in India. It was stated in the paper that Madras indigo in the early days was worse than other kinds, and it was well known that at the present time, three hundred years later, it still was so. He would like to know whether that was then a different kind from the indigo of Surat. It would also be interesting to know the different qualities of the large number of calico pieces that had been mentioned by the author as coming from India. It was often supposed that they were made from exceedingly fine types of cotton, but it was inconceivable to any one who had been engaged in agriculture in India that the whole of the Indian cotton crop in the old days was fine; there must always have been a much shorter staple cotton. One was led to wonder whether the old records would not also throw some light on the methods of industry formerly pursued in India, and how many of the articles were actually made and manufactured there. It was often said that in the old days India produced articles not only of exceedingly fine quality, but also of very great diversity, but the author's remarks on the subject of carpets seemed to convey the idea that it was a matter of very great difficulty in former times to induce the local workmen to alter their shapes and sizes, as it is to-day. An instance of trade persisting was the return trade of coral, which still went from Italy to India now, not through London, but by the aid of the banks, direct from the Italian merchants to the Indian dealers.

THE REV. FRANK PENNY (Madras Chaplain, retd.) said that for the past three hundred years there had been a great amount of misrepresentations as to the character of the men who worked in India for the East India Company in the early days. Those men, however, were the pick of the apprentices of the City of London, who had been educated at such schools as St. Paul's and Christ's Hospital, whose lists in the seventeenth century contained the names of many boys who afterwards distinguished themselves in India. There was a great deal of jealousy in this country on account of their success and the privileges, such as monopolies, that they enjoyed, and that jealousy gave rise to the false statements that had so often been made as to their moral character.

MR. G. P. BAKER said it must be observed that in connection with Mr. Foster's monumental work, on which he had been engaged for some years, the calicoes referred to in the period under review consisted of so-called printed and plain cottons. It might not be generally known that calico in the seventeenth and eighteenth centuries was never made in Europe at all but came entirely from India. The invention of calico printing was also due to India. In the early days, when the cotton goods came to England through the East India Company, they were sold either by public auction or by private sale, and then they were taken to the whitesters in the neighbourhood of London, who had their bleaching fields on the banks of the Wandle, the Lee and other rivers, and who had been taught how to bleach by the Dutch. Then would follow the dyeing of the Indian cloth and then the printing. The information about calico printing was not brought to this country by the servants of the East India Company but by the Jesuit Fathers. The balance of the trade was in favour of India until the era of invention when Arkwright invented the spinning-jenny and Watt the steam engine, and then the balance was turned in favour of England as against the East. Some of the most interesting documents in the library at the India

Office were the old warehouse sale books and catalogues of the East India Company. It appeared that the Governors of the Company held sales periodically, once in six months, the articles sold including saltpetre, coffee, china, porcelain, tea, shellac, and a very little cotton. The sales were extensively advertised and attracted many buyers from the Continent. The sale books showed that in 1660 the tea realised from 15*s.* to 18*s.* 3*d.* per lb., shellac £27 per cwt., and rhubarb 10*s.* 6*d.* per lb. The Carmania wool mentioned he supposed was Khorassan wool; it was a very fine quality wool and made the cardinal hats so popular in Europe at that period. In 1704 a six days' sale by the East India Company realised £255,000. With regard to calico prints—the section of the trade which he had been investigating—he found an entry showing that in one day 22,000 pieces of chintz were sold at from 8*s.* 3*d.* to 10*s.* 9*d.* per piece. It was interesting to note that many words well known in the Manchester trade to-day were derived from Indian words: for instance, chintz, dungaree, ginghams, dimities, and so forth. Mr. Foster, as a true editor of the records, had not indulged in the romance of trade to which the Chairman alluded. The doings of our merchant adventurers offered many stories, which he hoped might yet form part of Mr. Foster's work.

Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., F.R.S. (Director of the Royal Botanic Gardens, Kew), said that Mr. Chadwick had asked the author, with reference to the quality of the indigo produced on the Coromandel Coast as compared with the indigo of Surat, whether the two were the product of the same plant. That was a question which it seemed only fair to the author that a botanist present should answer on his behalf, and it was one that had already been examined and the evidence had been recorded. The references and specimens available indicated that Madras indigo was the product of the plant described in nearly all text-books dealing with indigo as *Indigofera tinctoria.* He believed, however, that *Indigofera tinctoria* never was used as a source of indigo to any appreciable extent except in Madras. Certainly the plant which yielded the indigo exported from Surat was quite a different one. That plant was still grown as a source of indigo in the Italian colony of Eritrea, and was still sparingly cultivated by the Indian natives themselves in Sind, Rajputana and the Kistna uplands. The author had mentioned that the Dutch on the Malabar Coast were the rivals of our people at Surat in the export of indigo to Europe. It was known from a Dutch author that another plant, different from the source of Surat indigo and from that of Madras indigo, was then cultivated in Malabar. It was that third plant, which was not of Indian but of Malayan origin, that, after the cultivation of indigo was taken up again by the East India Company towards the end of the eighteenth century, was grown in Bengal, Bihar and Orissa.

Mr. William Coldstream proposed a vote of thanks to the author for his paper, the motion being seconded by Mr. Laurence Currie, and carried unanimously.

Mr. Foster, in reply, said that, with reference to Mr. Baker's remark about Carmania wool, he thought that wool had nothing to do with Khorassan, but with Kerman in Persia, whose carpets and shawls were still valued. Sir Percy Sykes had done a great deal to revive the demand for them. He was very glad to hear the remarks Sir David Prain had made with regard to indigo, the information given being quite new to him.

On behalf of the Indian Section Committee, Sir Charles S. Bayley, G.C.I.E., K.C.I.E., thanked Mr. Chamberlain for presiding.

The Chairman, in concluding the meeting, said a correspondent had reminded him by letter that morning that the present year was the centenary of the death of Warren Hastings, and had suggested that the house in which he used to live near the Marble Arch should be marked by a tablet. He (Mr. Chamberlain) was under the impression that it was so marked, but if it was not, he thought the Indian Section might perhaps jog the memory of the London County Council, who frequently commemorated the association of great men with London localities. He only regretted that, on the other side of the India Office to that on which the fine statue of Clive stood, there was not a statue to the other great pioneer and founder of Indian government, Warren Hastings.

The correspondent alluded to by Mr. Chamberlain in his closing remarks, Mr. Wilmot Corfield (Calcutta Historical Society), writes pointing out that the house in Park Lane where Warren Hastings lived has been demolished and a new one erected. He suggests that a tablet should be placed, not upon the present building, but upon or near the park railings opposite, deferring the larger question of a statue to a more convenient season.

"FABRICATED" SHIPS.

One of the most interesting but least known developments of the present shipbuilding effort in which Great Britain has led the way is that of "fabricated" ships. It is described in the *Times* of April 18th. A "fabricated" ship is a vessel the component parts of which are manufactured in other than shipbuilding yards. These component parts are transported to shipbuilding yards, assembled there, and put together as complete ships.

When the State undertook the reorganisation of the United Kingdom's mercantile shipbuilding industry, the principle of standardisation was

naturally adopted because in mass production of a specific object the highest possible speed of output is obtainable. A series of standard ships were designed, and contracts to build them were given out to the private yards of the country. As supplies of steel and labour increased and promised a margin over and above the requirements of the existing controlled shipyards, the idea was carried a stage further. The fabrication of ships was decided on and the necessary provision made. The aim of the Admiralty Deputy-Controller's Department was still further to increase speed of production. As matters stood, all the shipbuilding yards, engine factories, and boiler shops were largely occupied with standard ship work. There were, however, many other industrial establishments in the country doing work closely resembling shipbuilding and marine engineering. Among them were bridge-building yards and land engine factories. The majority of them were in inland centres and remote from launching water; but, taken altogether, their resources were so great that it was felt that they ought to be used.

"Fabrication" solved the problem, and a ship was designed the material of which could be satisfactorily fabricated in the bridge yards. It is a bigger vessel than most of the standard ships, and there is not a curved frame in it. Size and weight of unit of construction are limited, so that transport is easy, and powerful gear for placing it in position is unnecessary. To avoid the same difficulties as regards machinery supply, geared turbines have been adopted instead of reciprocating engines. Every part of the complete ship can, in fact, be fabricated in inland establishments selected near the steel-mills which have never done ship or marine engine work, and can be transported by ordinary means to the seaboard. With all the slips in private yards filled, it was necessary to look elsewhere for sites for assembling yards. The national shipyards on the Bristol Channel were laid out for the purpose, and private undertakings of the same character exist or are projected with the concurrence of the Admiralty elsewhere. The objection has been urged that State-owned establishments ought not to have been set up until it was definitely known that the contract industry could not provide the required additional facilities. But it should not be overlooked that in carrying out its plans the State has a call on labour which is not available to contractors. The bulk of it is unskilled. Labour is, however, being trained in the use of pneumatic riveters and caulking tools, and will be (already it is in a large number of instances) sufficiently expert to put the assembled fabricated ships together.

The fabrication of the material of ships and engines has now been organised over a considerable area, local committees being responsible in certain districts for definite deliveries of a ship, or a number of ships, in specified periods. Moreover, fabricated ships are taking shape in several assembling yards. Before long, vessels of the type should represent a very considerable addition to the tonnage output. In the strictest possible sense of the term they will be additional, for their production will have involved absolutely no interference either with the contract industry or its supplies of labour and material. The State's fabricated ship enterprise increases the tonnage output by tapping new sources which are inaccessible or impossible to the private shipbuilder.

GENERAL NOTES.

Overseas Trade.—The following have been appointed to serve as a Committee to advise the Department of Overseas Trade (Development and Intelligence) on matters relating to the activities of the department: Sir Francis Barker, representing the Federation of British Industries; Sir Algernon F. Firth, Bt., representing the Association of Chambers of Commerce of the United Kingdom; Mr. W. H. N. Goschen; Mr. W. L. Hichens; The Right Hon. Lord Inchcape, G.C.M.G.; Mr. Walter Leaf; Mr. Kenneth Lee; Mr. G. A. Moore; Mr. J. W. Murray; Sir George A. Riddell, Bt.; Mr. C. V. Sale; Captain Albert Smith, M.P.; Colonel Frank H. Wedgwood.

Wolfram in Kedah, F.M.S.—A correspondent of the *Mining Journal* writes that the sanguine expectations entertained of the wolfram discovery at Sungei Sintok, near Changloon, Kedah, are being substantiated by further examinations. The ore is found in quartz, and, of course, systematic prospecting, which is to be taken in hand shortly, will be necessary before definite opinion can be formed. However, there can be no doubt the mine is rich, and the owners expect to get an output of at least fifty tons of concentrates per month. The ore is very coarse, and lumps weighing as much as fifty kattis are not uncommon. It is believed to be the richest find made in the East. A curious feature is that no extension of the deposit outside the original area has so far been revealed.

South African Timber.—It is not so very long ago that South African timber was, taken all round, considered of little value. Now that imported timber has gone up in the market, according to *South Africa*, many virtues have been discovered in the native timber which previously were unknown. In consequence, South African timber has come to the front, so that it figures prominently in many issues. Sawing timber, such as Cape pine, poplar, yellow-wood, blue gum, and other varieties, cut into standard deals of 3 in. by 9 in., is quoted at $10\frac{1}{2}d.$ to $1s.$ per foot. This timber is mostly used for boxes and packing-cases, as well as substitutes in the mines and buildings for the imported Baltic and Oregon woods. Mining poles and sawing timber are quoted at fair average values.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday afternoons, at 4.30 p.m.:—

May 1.—George Martineau, C.B., "Sugar from several Points of View." The Right Hon. Lord Balfour of Burleigh, K.T., G.C.M.G., G.C.V.O., will preside.

May 8.—John B. Farmer, D.Sc., M.A., F.L.S., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry."

May 15.—Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry." Sir John Stirling-Maxwell, Bt., will preside.

May 29.—Martin O. Forster, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." Sir William A. Tilden, D.Sc., LL.D., F.R.S., will preside.

Indian Section.

Hon. Sir Dinshaw E. Wacha, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

[The date will be announced later.]

Colonial Section.

Tuesday afternoon, at 4.30 p.m.:—

April 30.—Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17, "British Guiana." Sir Everard im Thurn, K.C.M.G., C.B., will preside.

Special Lectures.

A special course of three lectures on "The Freedom of the Sea" will be delivered on Thursdays, May 2nd, 9th, and 16th, at 4.30 p.m.

Lecture I.—By Gerard Fiennes. Chairman, J. L. Garvin.

Syllabus.

The Freedom of the Seas.

Freedom without Law.—The first maritime peoples—The Viking Age—Edward III. and the sovereignty of the seas—The Hansa—The Italian Republics in the Mediterranean.

Law without Freedom.—The discovery of the passage round the Cape of Good Hope and of America—The Bull of Alexander VI.—Henry VII.'s licence to the Cabots—Elizabeth's views—The English and Dutch—The war of Jenkins's Ear—The mercantile system—Berlin decrees—Orders in Council.

Law and Freedom.—Britain's work—Freedom "made in Germany."

Lecture II.—By Sir Francis Taylor Piggott, M.A., LL.M., Chief Justice of Hong-Kong, 1905–12. Chairman, Lord Sanderson, G.C.B., K.C.M.G.

Syllabus.

The Freedom of the Sea in War.

The breakdown of International Law due to unpractical theories—Effect of war on the Freedom of the Seas—Limitations of neutral commerce with the enemy—Rule of 1756—All interference with neutrals based on prevention of assistance to the enemy—"Free ships, free goods": the neutral doctrine essential to maintain the enemy's fleet—Foundation of a spurious Freedom of the Sea claimed by enemies and neutrals: consistent opposition to the doctrine by England—The armed neutralities—American War of Independence—Bonaparte's theories—Immunity of private property at sea—Declaration of Paris—Maintenance of English principles of belligerency essential to an effective League of Nations.

Lecture III.—By John Leyland. Chairman, Admiral Sir Edmond John Warre Slade, K.C.I.E., K.C.V.O., R.N.

Syllabus.

The German "Freedom of the Sea."

Britain the great upholder of the Freedom of the Seas—The meaning of the term—How it was regarded by Grotius—How we came to be denounced as the "tyrants of the sea"—The attitude and policy of Napoleon—His claim to be the liberator from tyranny—The modern German claim a protest against British sea-power—An analysis of the claim—Its real meaning—The view held and expressed in the United States—The agreements and understandings with Prussia—President Wilson's declaration—How it is in conflict with the German claim—The need of a right understanding of the subject.

Cobb Lectures.

"Recent Developments in Leather Chemistry," by Henry R. Procter, D.Sc., F.I.C., Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University, Director of the Procter International Research Laboratory. Two Lectures.

Syllabus.

Lecture I.—May 13.—Structure and chemistry of skin—Processes for removal of hair and epidermis—Removal of lime and preparation for tanning—Use of bacteria and enzymes—Dehydration and separation of fibrils—The pickling process—Nature of colloid swelling.

Lecture II.—May 14.—The conversion of the pelt into leather, and the nature of the change—tannage with mineral salts—Alumina tannage—Chrome tannage—Vegetable and synthetic tannins—Tannages with aldehydes, quinones and bromine, and with colloidal precipitates—Oil tannage—Summary.

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NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 8th, at 4.30 p.m. (Ordinary Meeting.) JOHN B. FARMER, M.A., D.Sc., F.R.S., Professor of Botany, Imperial College of Science and Technology, "The Rubber Planting Industry." SIR EDWARD ROSLING, Chairman of the Rubber-Growers' Association, will preside.

THURSDAY, MAY 9th, at 4.30 p.m. (Special Lecture.) SIR FRANCIS PIGGOTT, M.A., LL.M., Chief Justice of Hong-Kong, 1905–12, "The Freedom of the Sea in War." LORD SANDERSON, G.C.B., K.C.M.G., will preside.

Further particulars of the Society's meetings were published in the last issue of the *Journal.*

COLONIAL SECTION.

Tuesday afternoon, April 30th; SIR EVERARD IM THURN, K.C.M.G., C.B., in the chair. A paper on "British Guiana" was read by SIR WALTER EGERTON, K.C.M.G., LL.D., Governor of British Guiana, 1912–17.

The paper and discussion will be published in a subsequent number of the *Journal.*

NINETEENTH ORDINARY MEETING.

Wednesday afternoon, May 1st; The RIGHT HON. LORD BALFOUR OF BURLEIGH, K.T., G.C.M.G., G.C.V.O., in the chair. A paper by Mr. GEORGE MARTINEAU, C.B., on "Sugar from Several Points of View" was read by Mr. EDWARD R. DAVSON, President of the Associated West Indian Chambers of Commerce.

The paper and discussion will be published in a subsequent number of the *Journal.*

SPECIAL LECTURE ON "THE FREEDOM OF THE SEAS."

Thursday afternoon, May 2nd; Mr. J. L. GARVIN in the chair. A special lecture on "The Freedom of the Seas" was delivered by Mr. GERARD FIENNES.

The lecture will be published in a subsequent number of the *Journal.*

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FRIDAY, MAY 3, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

SIXTEENTH ORDINARY MEETING.

Wednesday, April 10th, 1918; PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., Director of the John Innes Horticultural Institution, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Barrett, Frank, Grimsby.
Campbell, Oliver Hering, London.
Chopra, Igbal Chand, India.
Cobbett, Colonel George Talbot Burrows, London.
Cockill, Harry, Southport.
Davies, Frederick Herbert, London.
Dobson, D. Bennett, Thames Ditton.
Feltoe, Rev. Charles Lett, D.D., Dover.
FitzGerald, Francis William, London.
Forbes-Bentley, Lieutenant Rupert, Beckley.
Harrison, Joseph, Hon.A.R.C.A.(Lond.), Nottingham.
Hugh, James, Bothwell, Scotland.
Ishii, Shinji, London.
Lathe, Alfred, Bilston.
Nisbett, G. H., M.I.E.E., Liverpool.
Reddan, William Holmes, Mansfield.
Singer, Edgar Ratcliffe, Frome.
Statham, Noel, New York City, U.S.A.
Taylor, Arthur Walford, London.
Tuck, G. O., Kentucky, U.S.A.
Underwood, Oliver, London.
Watson, Charles Edward, Wall, North Tyne.

The following candidates were balloted for and duly elected Fellows of the Society:—

Aiyar, K. V. Venkataramana, Madras, India.
Besant, A. Digby, London.
Boyd, John T. M., New Zealand.
Butson, Cecil W., Hankow, China.
Hosain, Dr. S. A., Mambuw, Federated Malay States.
Jackson, Right Hon. Frederick Huth, M.A., London.
Meling, Einar, Norway.
Muntz, Sir Gerard Albert, Bt., Stratford-on-Avon.
Narasimham, G., Madras, India.
Preston, Arthur Phillips, Teddington.
Rae, William, M.Inst.M., Kinlochleven, Argyllshire.
Simkins, Alfred George, London.
Spencer, Samuel, Assoc.Inst.C.E., London.
Stephens, Albert John, Gloucester.
Webb, Herbert Charles, London.
Wilson, Edmund Richardson, L.R.I.B.A., New Zealand.

THE CHAIRMAN, in opening the meeting, said that he had known Dr. Balls for many years as a vigorous and active worker both in the domain of pure science and in that of the application of science to the production of cotton. Science had scarcely yet been applied at all to the tropical and sub-tropical branches of agriculture. A good deal had been done in our own country in regard to agriculture, but very little in regard to tropical agriculture. For instance, anyone who knew something of genetic science and its possibilities, in walking over rubber plantations in the Malay Peninsula would feel amazed at the practices which still prevailed amongst planters there, and he was quite sure that the application of a trained intelligence for a few years would work a revolution. The good, bad, and indifferent plants were being cultivated. One rubber tree would produce two hundred units of rubber, and another only one, but all sorts were grown together in a batch, occupying equal space and attention. In a reasonable time it would be possible to produce a pure strain of best trees only. The same thing also applied to coco-nuts. Mr. Balls had experience of the sub-tropical plant, cotton, and he had added much to our knowledge of that subject.

The paper read was—

SOME APPLICATIONS OF RESEARCH TO THE COTTON INDUSTRY.*

By W. LAWRENCE BALLS, Sc.D.,
Late Fellow of St. John's College, Cambridge; Fine Cotton Spinners' Association; formerly of the Khedivial Agricultural Society of Egypt, etc.

Most of the research data to be utilised in this paper relate only indirectly to that section of the cotton trade which is most familiar to us at home; but it should be obvious that any knowledge of the nature of the raw material must necessarily react upon its control and utilisation.

* In the course of the paper, as delivered, lantern-slides were employed to illustrate the statistical data quoted. For the convenience of readers of the present text who may desire to study the matter more closely, a reference to these is made (where such are drawn from data already published) by giving the abbreviated title of the publication and the figure number within such publication. The publications used and their abbreviations are as follows:—

"The Cotton Plant in Egypt." Macmillan: London, 1912. (C.P.E.)
"The Development and Properties of Raw Cotton." A. and C. Black: London, 1914. (R.C.)
"Analyses of Agricultural Yield." Parts I. to III. *Phil. Trans. Roy. Soc.*, 1915–6. (A.A.Y. I., II., III.)
Reference to other papers by the author are given by a single number in parentheses, this number referring to the full list of such papers given in the first two books above mentioned.

Introduction.

The whole technique of the cotton manufacture—our largest export industry—is based upon the properties of single unicellular seed-hairs. Until we know the properties of those hairs, which in its turn requires a knowledge of the manner in which they are formed, and particularly until we know those properties in relation to their behaviour in the process of spinning, we cannot attempt to construct a common scientific language by means of which the Grower and the User of cotton may exchange ideas and information, and so may work together in order to produce the best practicable results from their raw material. This raw material is not so much the cotton hair itself, but is rather the sex-cell of the cotton plant, and the embryo relating therefrom.

Most of the audience will probably admit that our perspective of the cotton trade is exaggerated. We see the magnitude of our Lancashire cotton industry, we are properly impressed by the ingenuity and organisation which it involves, and we scarcely perceive a glimpse of that which lies behind it in the shape of agriculture. In the previous paragraph we have tried to correct this perspective, so as to obtain a general view of the cotton trade as a whole.

The study of the cotton crop is naturally subdivided into two halves of identical importance. Those halves are—the plant itself, and the environment in which it lives.

Any particular plant has certain constitutional capabilities, which may be peculiar to itself, or similar to those of its neighbours. These capabilities have been transmitted to it by the action of what we call heredity, and are fixed for it definitely at the moment of fertilisation. Such constitutional idiosyncrasies, however, resemble those of a photographic plate—which may be fast or slow, red-sensitive or blue-sensitive, and so forth—in that they are potentialities only; these potentialities have to be *developed* by the interaction which takes place between the organism and its environment in the process of growth and existence, just as the potentialities of the plate are developed in different ways by the action of different intensities and colours of light.

It is really somewhat remarkable that this very definite distinction has been so frequently missed. Many well-intentioned agriculturists have endeavoured to make "silk purses from sows' ears" by growing unsuitable seed in suitable places. Others have cast the pearls of good seed before swine by planting in unsuitable localities.

The examples with which we propose to deal to-day are all inter-connected, and relate to all parts of the cotton trade. They are as follows:—

In the first place, the preparation, propagation, and cultivation of pure strains or pure lines of cotton plants. Arising out of the study of these plants, we can examine what is meant by the length of the lint; the full investigation of this has only become possible quite recently, by means of a new piece of scientific apparatus. Thirdly, we shall sketch a history of the study of root asphyxiation in relation to the Egyptian cotton crop, an issue involving many millions of pounds; and in the course of so doing we shall see in the fourth place how this study compelled the natural development of new methods for examining and recording the state of the cotton crop, and thus incidentally provided practical means for making precision crop reports and forecasts.

The Cultivation of Pure Cotton.

The greater precision brought into the study of heredity by the re-discovery of Mendel's Law led to a class of work which was first exploited by Professor Johannsen of Copenhagen, known as pure line studies, or pure strain studies. Johannsen worked with beans and showed that from cultures of bean plants, which were considered uniform from a horticultural standpoint, it was possible to isolate many separate kinds which differed, for instance, with regard to the average size of the seed they produced.

When the author began his researches into the course of heredity in cotton in 1905, we had very little previous knowledge to guide us. A general conviction existed that the yield of the Egyptian cotton crop was deteriorating, and there was an impression (which we now know to be erroneous) that this deterioration would be dealt with primarily by appropriate breeding of new kinds of cotton. Certainly, although there was a general impression that uniform cotton was better than irregular cotton, we did not anticipate the possibilities which lay behind a mere repetition of Johannsen's studies, using the cotton plant instead of the bean plant.

It will assist understanding if we sketch briefly the early history of this work. We began by taking natural seed from single plants of the 1904 crop, and raising small families from these in 1905. Using methods suggested by analogy with previous experimental work (conducted as an assistant to our Chairman of to-day, and to Professor Biffen), the detailed

examination of these families showed in the course of 1905 that the commercially-grown seed with which we had started was very far indeed from being the seed of "pure lines" in Johannsen's sense (5, 8).

In the first place, even though we were not able to examine more than a limited number of the characteristics of the plants, and although the families we raised were quite small, it was most unusual to find a family in which all the plants resembled one another. It should be added that by the word "resemblance," we mean constitutional resemblance; the distinction between peculiarities of a plant due to its constitution as against peculiarities due to accidents of the environment, was decided partly by *à priori* reasoning in the first instance, and determined accurately by experiment in subsequent years.

Now, the fact that a group of plants derived from a common parent was not constitutionally uniform, indicated that the parent plant must have been a hybrid, and this great abundance of hybrids thus detected in those plants of 1904 which we had taken at random to begin with, indicated that an appreciable amount of intercrossing must be taking place between flower and flower under the conditions of the ordinary Egyptian field crop of cotton. Further, even with this rough material from which we started, we were able to show in 1905 that certain plants on our plot had undoubtedly originated through cross-pollination in the previous year and not earlier.

This work was extended to provide a numerical determination of the chance of crossing as compared with the chance of self-fertilisation, which chance was found to be approximately one in ten (C.P.E. Chap. 7). This amount of crossing is amply sufficient to contaminate hopelessly any pure line pedigree within only two or three years; thus a serious experimental difficulty with which we had thenceforward to contend was the prevention of crossing on the breeding-plot. It should be added that this conclusion concerning the chance of contamination by crossing in the cotton crop ran counter to almost all accepted notions on the subject; but was confirmed quite independently in the following year by Mr. H. Martin Leake, in India, and by many others since, while our own researches showed later that certain circumstances could produce much higher rates, rising even to ostensibly complete prevention of self-fertilisation.

In this early stage of the researches it seemed (as indeed it was) much more useful to attempt to trace the working of Mendel's Law by study of these natural hybrids, or, better still, by the deliberate making of hybrids for experimental purposes, than merely to isolate pure lines. Acting in the spirit engendered by association as a student with our Chairman, in tackling the difficult subject where apparent anomalies abounded, rather than the easy one, our further experimental work was directed primarily to the study of crosses between American upland cottons and Egyptian—practically an inter-species cross—rather than to inter-Egyptian crosses (15, 20, 33).

The attempt was an ambitious one, and was only made possible by the enlightened attitude of the Khedivial Agricultural Society, and its then president, the late Sultan of Egypt; it was, in fact, much more than a one-man proposition, or even a two-man proposition. At the same time it was well worth the trouble, for in many cases we traced definite simple rules of inheritance on Mendelian lines through most complex phenomena (C.P.E. Figs. 53, 69, 70), and in even more cases we found most complex inheritance in pedigrees which, on the face of them, appeared to have been quite simple (19).

The characteristics of commercial value are nearly all measurable characteristics, such as length and breadth and thickness, and are rarely "attributes" such as colour. As our work extended to the study of the inheritance of these measurable features, we were continually faced with the difficulty that we did not know enough about the effect of the environment upon the degree of manifestation to which such characteristics attained; we did not know to what extent or in what manner a cotton plant which had inherited long lint hairs might have those hairs shortened, or even made longer, by the action of the environment.

So many problems of this kind arose, and they were so often of obvious practical interest as well as being fundamentally important in relation to our researches on heredity, that the work of my assistant—Mr. Holton—and myself was diverted more and more, up to the end of 1912, to this aspect of the cotton plant, with results to which we shall return later in the course of this paper.

At the end of 1912 came an insistent official demand from the Agricultural Department, to which we had been transferred, for a new cotton to replace the deteriorated Brown Egyptian or Afifi (32). One thing at least was perfectly obvious, in the light of our seven years' experience, namely, that it was the easiest thing in the world to introduce a new cotton

Alternatively, one of the most difficult things in the world was to predict what the agricultural behaviour of plants in bulk would be, from the behaviour of a few parent plants grown on a breeding-plot. Lastly, it was self-evident to us, though apparently not to others, that to introduce a new variety of cotton in an impure state (however slight the percentage of impurity), or even allow it to become contaminated by natural crossing (much less by seed mixture), during its propagation from the breeding-plot to field cultivation, was simply to condemn one's work to the same failure which had sooner or later resulted with every other variety of cotton which had ever been developed in Egypt or anywhere else in the world. This meant, in practice, that a system of continual seed renewal was inevitable.

Thus, so far from being a matter which could be determined or settled by the work of one or two scientists, it was an administrative proposition, based on scientific research and involving a revolution in the system of seed supply for Egyptian cotton.

The prospects of this revolution were accepted at the time, and a system of pure-strain seed-supply was initiated, though it was never carried through to completion.

In developing this system, we had first to consider what cotton should be propagated as most nearly meeting the official demand. Obviously, the prime essential was that the strain should be a pure one; further, it was undesirable to introduce the use of any but Egyptian stocks. All strains bred from our deliberate hybrids of American or even Egyptian cottons were therefore ruled out, and we restricted our work to strains which had been obtained simply by choosing individual plants of commercial Egyptian varieties. These plants and their descendants had been self-fertilised for a number of generations ranging from seven to two, and all their various characteristics measured, registered and studied until such of them as had been hybrids originally had been split down to purity.

One strain known as No. 77, whose pedigree dated back to 1904 and had been published in some detail (5, 15, 33), which we had used as a parent in our crosses with American cottons, seemed to be moderately suitable for tentative trial (32), though the direction of our past work had not been towards a deliberate isolation of the best Egyptian cottons from the existing mixtures (7), but rather towards the study of heredity in cotton in the hope of ultimately making more radical improvements.

Another strain of brown cotton called No. 95, was propagated side by side with this (C.P.E. p. 109), and one from long cotton known as No. 310 was put forward out of curiosity, to see whether it was possible to grow lint in Egypt of the same order of quality as that of the Sea Islands. Simultaneously, the study of inter-Egyptian crosses and the isolation of more pure strains of Egyptian cotton was extended in the search for ideal plants, and No. 111 was found, purified and propagated to a ton of seed between September 1911 and November 1913; but most of our energies for the next two years were expended on devising and executing means (34) whereby these four pure strains could be propagated into sufficient quantity to sow fifty or a hundred acres of land without contamination from other cottons by natural crossing.

Without entering into details, we may note that most of the transference of pollen from flower to flower in Egypt is effected by bees; if bees can be kept away, foreign pollen is also kept away, and so for the first stage we sowed the protected seed from single pure-strain plants in cages built up of angle-iron and brass-wire gauze of 144 apertures to the square inch, each cage measuring 10 metres by 14 in area, and 2 metres in height, built partly on a system of sectional unit panels of gauze which we designed.

For the following year (1913) the seed from these cages, again spaced at wide intervals so as to obtain the largest possible production of seed per plant, covered areas of 20 acres or so, and obviously could no longer be protected by gauze, so we endeavoured to deceive the bees by surrounding such areas with a belt of plants some seven to ten rows deep; these were plants nominally of the same strain, for whose parents we had not been able to find room for protection in the cages in the previous year. The motive behind this arrangement was that any bee reaching the propagation plot after visiting ordinary cotton outside, should, so to speak, filter itself upon the plants of the Belt from some at least of the foreign pollen which it carried, before reaching the cage-bred and pure plants of the main plot. The seed from the plants growing in the Belt was destined, of course, to be destroyed.

Such was, in outline, the system we devised, and this was to have been combined with a system of seed distribution year by year, so as to provide for continual and perpetual renewal, of the seed of all Egypt year by year as a matter of pure routine from the handfuls of various suitable strains, maintained pure with all laboratory precautions, at the Central Seed Station at Giza; the inevitable deterioration of a variety of cotton exposed to contamination

in the field would thus be counteracted by continuous renewal year by year from the pure stock.

Seed mixture and natural crossing can be prevented by the usual research precautions in the laboratory; on the propagation plot they can be minimised by arrangements of belting and by zonal collection of seed, but it is hopeless to attempt to prevent such contamination at a later stage. It must inevitably take place, until we can discover or breed a cotton plant which is naturally self-fertilised. Further, the effect of such mixture augments itself enormously year by year, so that the presence of 2 per cent. of natural hybrids in a handful of pure-strain seed can convert 30 per cent. of the individuals in that strain into rogues at the end of only three years (32).

It may be noted incidentally that during the course of this work we raised more than a metric ton of apparently pure seed by the autumn of 1913, where a single seed had been planted in 1911, and this not once, but in the case of three separate plants. I believe that this is practically a record for artificial seed propagation, and I look back now with some amusement on the fact that, though it was achieved in the teeth of almost every conceivable misadventure, I was informed that it was much too slow.

With the departure of Mr. Holton, and then of the author, from Egypt at the end of 1913, this work was practically put in abeyance.

Trials were made of these four strains, and No. 111 turned out to be definitely superior to any other Egyptian cotton from the agricultural point of view, justifying our judgment in choosing it deliberately. No. 95 was remarkably and unexpectedly good in every spinning test. The strain first elected for propagation as being thoroughly well known (No. 77) turned out only moderately successful, as had been expected at first (32), while the very long cotton (No. 310), although its yield was no better than we had anticipated, showed that Egypt could grow cotton comparable to that of the Sea Islands, if she cares to take the trouble.

The most important result, however, of all this mainly wasted effort, was that these pure-strain cottons, when put through the spinning-mills, behaved far better than expert judgment and handling of the lint had anticipated. Perhaps the most remarkable case was that of a very ugly sample of No. 77, with regard to which the author received two letters from the spinner at intervals of a week; the first letter stated that the sample was very bad, but it would be included in the spinning tests solely because of the interest attaching to any performance of these pure strains. The second letter showed that this ugly duckling had headed the list of six samples in the test, giving the strongest yarn of any. We are ignorant as to what this peculiarity may mean; but it can scarcely be accidental that three strains, chosen at random from the Egyptian cotton-complex, without any knowledge whatever of their spinning possibilities, chosen merely because they happened to be the only well-known pure strains available, should falsify the expectations of expert judges of raw cotton in this manner.

The cultivation of these four strains has now been abandoned, but two further facts may be noted. Firstly, that No. 111, isolated in 1911 from Assili, was an excellent cropper, and was indifferent only in the spinning tests; yet it was as perfect in the uniformity of its lint-length as any cotton known; undoubtedly there is something lacking in our text-book precepts. Secondly, at least one strain which had been isolated since 1906, and had been still pure at eight years old when sown in the field in 1914, was badly contaminated by 1917; caging or seed-renewal had not been practised, but only especial care in handling the seed: our predictions as to the importance of natural crossing are thus completely fulfilled.

Length of Staple.

One of our most pressing needs at the present time is the provision of a language common to both the spinners and the growers of cotton, such that the grower can be informed exactly what kind of cotton the spinner requires (R.C. Chap. V.). This language can only be synthesised by scientific study of the properties of yarn in relation to the hairs of which it is composed.

Amongst the many physical properties of cotton hairs, one of the most obvious is the length. We may now proceed to indicate the difficulties involved in the study of this simplest of all the hair properties, from which may be gathered some idea of the nature of the elaborate technique which has yet to be constructed patiently, before this scientific analysis of a practical matter can be carried far enough to provide the common language which we need.

It will have been gathered from the previous section of this paper that the ordinary commercial crop of cotton is an impure culture, which, from the genetic standpoint, is so far from being a pure strain in Johannsen's sense that it approaches rather to an analogy with Humanity; for although each individual plant is not unique in constitution, yet there are innumerable differences existing within a single field. Amongst these differences are those relating to the length of the lint, over and above such modifications of lint-length as may be

caused by environment. Further, these genetic differences take two forms: firstly, there are differences in what we may call the Mean Maximum length of the lint produced on any one seed, and, secondly, there are differences in the degree of Variation in lint-length on different parts of the same seed. Consequently, in respect of the latter, a single plant (or equally, a pure-strain population of plants) may produce most irregular lint, the hairs from one end of each seed being very much shorter than those from the other end, while every graduation is found between these extremes. On the other hand, suitably chosen pure strains are capable of making lint not only more regular in staple than are our present cottons, but may conceivably produce a greater degree of natural regularity than machinery can enforce.

It probably needs no further explanation for the reader to see that any detailed study of the influence of environment upon the inherited lint-length capacity of the plant was obliged to wait until pure strains could be cultivated more or less in bulk; otherwise the environmental effects were likely to be masked under the constitutional mixture, this mixture being not only a mixture of lint-lengths, *qua* lint-lengths, but also a mixture of reaction-capacity for the operation of building up lint-lengths.

Our possession of this pure-strain material enabled us to conduct a series of determinations day by day, throughout two separate growing seasons, showing the effect of various conditions of soil and weather in modifying the length of the lint. These have been published in book form (R.C., especially Figs. 14 and 15), and we need not further mention them here except to say that these variations were all traced to comparatively simple causation.

In all these studies, however, until last year, we had not a full technique at our disposal, and since this is the point of immediate interest a short explanation of the way in which the length of staple is ascertained must now be given.

In the ordinary way, the length is determined by examination of the lint cotton, from which the seed has been removed in the process of ginning. The expert grader pulls a tuft of hairs from this lint in a particular manner, usually lays the tuft on his coat sleeve, and then assesses, with or without a measuring scale, the length of the tuft: in this case, the length measured is the length of the majority of the longer hairs; it is not the length of the few very long hairs, since these are not conspicuous enough to show up on the dark background; it is not the length of the shorter hairs, because these are hidden by the long ones, or even are left behind in the process of pulling the tuft. The grader's "length" is in itself somewhat difficult to define, although it is sufficiently well understood for ordinary working purposes of comparison.

Various methods have been tried in order to bring greater precision into these definitions. In 1863, Mr. C. O'Neill measured a few dozen cotton hairs one by one, and published the data obtained, which have been frequently quoted. Other similar sets of determinations have since been made, but the difficulty inherent in all these methods is that of sampling; it is extraordinarily hard to ensure that the hairs removed for measurement are free from even a moderately high "sampling error"; the advantages of these methods, apart from their sampling error, would be the provision of data as to the percentage of short fibre in the sample, which is a very important factor in predicting the waste which will be made during the spinning process, and at the same time is one which even the most expert grader cannot be completely trusted to assess correctly.

There is an alternative way of measuring length of staple, which practically disregards the waste component, and being effected upon the seed-cotton is therefore useless to the users of the ginned lint. It began with the practice in America of combing out the lint hairs on either side of the seed in the form of two wings, and measuring the length of these two wings.

When the author began his study of cotton, it seemed self-evident that this was a bad way of doing a good thing, for if the hairs were combed differently, so that they formed a halo round the seed with each hair lying approximately along a radius of the halo, and with the longitudinal axis of the seed lying in the plane of the halo (R.C. Pl. V), then the cotton which produced a circular halo with the seed in the centre was obviously more uniform than that which gave an eccentric halo, so that the method provided some indication of regularity of staple.

Apart from this, however, and confining our attention to the mean maximum width of the halo, commonly attained at the butt of the seed, it was found that this could be measured to within a millimetre, and, as data accumulated, we found further that by so doing we had obtained an unexpectedly precise method of lint measurement. The probable error of the measurement made in this way on so few as seven seeds, taken at random from any one plant,

was no greater than the error of measurement from two dozen single-lint hairs even without considering the sampling error of the latter; the adoption of this method alone enabled twenty plants to be studied for every one which could have been studied by the old method, and it is now in general use.

The limitation to the method was its inapplicability to ginned lint, and hence to all consumers' problems, while a further limitation resided in the fact that it gave a numerical statement of the mean maximum length only, and not of the frequency distribution of short hairs in the sample. This latter could only be assessed conveniently by eye-judgment. Consequently, some method was most obviously needed which would handle ginned lint; would handle it in sufficient quantity to blot out the sampling error; would determine, not only the mean maximum length, but also the distribution of lengths of all kinds; and, equally important, would do all these operations quickly.

This method is now available through our invention of a comparatively simple mechanical arrangement which can be worked up to various degrees of operative complexity for the sake of making the mechanism automatic; a provisional patent has been obtained, and one form of it is shown to-day, by the courtesy of my Directors in the Fine Cotton Spinners' Association.

This Length-Sorting Machine consists primarily of a pair of revolving rollers which, as they revolve, are traversed, or translated bodily, along a path at right angles to their axes of rotation. The cotton to be examined is first run through ordinary drafting mechanism, so as to cause the hairs to lie parallel and straight, and this "sliver" is presented to the rollers at the beginning of a traverse until they have seized a millimetre or so of the front ends of the foremost hairs. The sliver is then drawn away, leaving in the nip of the rollers a tuft of hairs which are all held by their front ends.

The rollers continue to revolve, and obviously the first hairs to be delivered from them on the other side will be the shortest hairs, while the longest hairs (since all started with their front ends level) will be the last to escape. But since this feeding action of the rollers is combined with, and positively geared to, the motion which causes the traverse, it follows that the short hairs will escape on to a suitable collecting device at the beginning of the traverse, the long ones at its completion, and intermediate lengths at intermediate points. Thus the cotton is fractionated by a continuous cycle of operations, repeated as many times as is convenient, not merely into separate parcels of hairs, but into a graduated series which may be sub-divided to any degree desired.

Simpler forms of this machine would seem to offer possibilities of useful application in all places where experimental cotton-growing is being carried out. At any rate, we now possess a technique by which we can take a sample of raw cotton, make it into a sliver, treat that sliver for two minutes only in an automatic machine, weigh the graduated produce of the machine's activity, and, at the end of half an hour can plot frequency curves of a reasonable and measurable degree of precision, showing the variation of length of staple within a sample.

Frequency curves showing some environmental variations in this respect, by the four pure strains previously described when grown at different times and places in Egypt and the Sudan, illustrate very well the differences which can exist between different cottons both as regards heredity and environment. It is particularly interesting to note the uniformity of the lint of No. 111, which was the only one of the four strains deliberately chosen for likely agricultural virtues; these virtues included an extremely high percentage of lint per unit weight of seed cotton, a boll which opened nicely, an ability to produce bolls in pairs instead of singly, and an arrangement of lint on the seed which, when combed out, gave an ideal form of circular halo surrounding the seed almost equally in all directions. The effect of this last characteristic is clearly shown in the form of the curve for No. 77, which was noted on the very first seed ever handled (5) as being defective in this respect.*

The Root and the Water-table.

The period from 1895 to 1899 has been described as being the "high-water mark of Egyptian cotton-growing." The area under cultivation with cotton was about 1·1 millions of acres, and the yield per acre was about 540 lb. of lint. Since that period, the area under cultivation has risen to about 1·7 millions of acres (the maximum before the war); but the total increase in quantity of cotton produced by this great increase in the amount of land, labour and water devoted to the crop has been trivial.

* The existence of a mechanism for sorting wool, invented by Herr Schlumberger, came to the knowledge of the author recently through the courtesy of the Bradford Conditioning House's manager, just two years after the first inception of the present machine, and one year after it came into routine use. The Schlumberger instrument, while accurate and useful, is intermittent and non-automatic, and does not employ the traversing roller.

The total quantity of cotton produced by Egypt at the present time stands to the amount produced twenty years ago in the ratio of 6·5 to 6·0; it follows that the effort involved in raising the cotton area by 600,000 acres has given a very small benefit if measured in terms of cotton alone.

During the last few years, the issues involved in this remarkable phenomenon of yield-deterioration have been somewhat obscured by the incursion of a new insect pest, the pink boll-worm, which was first seen in Egypt in 1910, caused damage locally on a commercial scale in 1912, and was the cause of very serious loss and damage to the crop in 1913 and afterwards. Prior to 1912, however, there was no question of pink-worm effects, and even since that year it is perfectly clear, as we shall see later, that much of the damage attributed to the worm, definite though this latter is, has really been due to the same causes which had already brought about the yield-deterioration between 1898 and 1912.

On the first page of the first laboratory note-book which the author started in Egypt, is a summary of the position of cotton problems given to him by Mr. G. P. Foaden, during his first morning at the Khedivial Agricultural Society, stating that there seemed to be at that time, namely, the end of 1904, some reason for believing that the yield per acre was steadily diminishing, owing to some unknown cause, and that this diminution was not merely accidental.

Matters were slightly complicated in 1905 by the exceptionally bad attack of the ordinary boll-worm, which had been known in the country since 1876, though its effects had generally been confused with those of fog and cool weather. As this diminution became more obviously a serious matter, numerous explanations were adduced. We need not discuss these here (27), since they have all been shown to be invalid by actual statistical analysis of the facts, although even at the present time these exploded fallacies are frequently reasserted by reactionaries; the extension of cultivation of land which previously had not grown cotton and the use of artificial manures may be cited as examples.

In the spring of 1906 Mr. J. R. Gibson, English Commissioner for the State Domains —who, in collaboration with his chief engineer, M. Audebeau, had been experimenting and observing during the past year on the basis of a working hypothesis which they had constructed —came to the author's laboratory one morning and informed him that there seemed to be good evidence in favour of their novel interpretation, to wit, that the falling-off in yield was due to a rise in the level of the sub-soil water, or water-table, of the country in general, which rise had been brought about by the extension of the irrigation system during the past decade.

For our present purposes we need not go further into this part of the matter (5, 11, 16, 17, 29). The view was decidedly unpopular, since it necessarily involved criticism of what was then, and must necessarily be, the most powerful and important department of the Egyptian Administration.

The death of Mr. Gibson in 1909 was a serious loss to the increasing body of scientists now converted to this view, while a very early flood in the same year brought the average yield obtained (from one of the most promising crops which Egypt had ever seen) down to the catastrophic figure of 324 lb. per acre, and caused the matter to become very serious politics.

Commissions and committees deliberated on the problems, and in at least one case a committee was appointed and never met at all; but the facts discovered year by year, through the activity of a small school of scientific investigators, were too strong to be still obscured by prejudice. Administrative changes took place, and the present Irrigation Department adopts as part of its fundamental tenets the view that a high or rising water-table is bad for the cotton crop.

At the same time, it is doubtful whether, owing to the complication introduced by the pink boll-worm, it is even now recognised how important the water-table is as a factor in determining the yield of the crop. We shall return to this matter later, and it will suffice for the moment to state the problems in biological terms.

The two originators of the water-table hypothesis were irrigation engineers and agriculturists, not biologists, and so it necessarily fell to the author as the only professional student of plant physiology in Egypt at the time, to develop the biological side of the case, which consisted in the study of root-function and of root-asphyxiation. In passing, it may be mentioned for the guidance of those biologists who may find themselves in a similar predicament, in any country or for any crop, that the most difficult aspect of the whole controversy was that scarcely anybody had the glimmerings of an idea that the root was a living thing, that it required oxygen for its respiration, that if its oxygen supply were cut off, as by immersion in stagnant water, it would die, and that if the

root were dead it would no longer carry on its functions. Controversy on such a subject, under these limitations, was rather like endeavouring to carry on a fight with both hands in handcuffs, and there is no doubt that far more rapid progress would have been made if the scientists had stated their case without scientific reserve.

Year by year, and little by little, from 1907 onwards, our knowledge of the function of the root of the cotton plant increased. As it increased, we realised how small was our knowledge of root-function in any plant, beyond the comparatively elementary facts of the text-books, so that to a very great extent we were not simply applying to the cotton plant the general scientific principles involved, but were semi-consciously building up a general scientific knowledge of root-function, worked out on the cotton plant as our material.

Our preliminary results in this study of the root disclosed a structure of unexpectedly large dimensions. The ordinary field crop of Egyptian cotton is planted in such a way that the plants stand together in pairs, each pair separated from the next pair along a ridge by an interval of about 40 centimetres, and each ridge from the adjacent ridge by about 80 centimetres.

We first showed by excavation and hydraulic mining on a small scale with a needle-jet of water, that the root system in soil which possessed a deep water-table (or had possessed a deep water-table until the autumn), could be traced to a depth of more than two metres, while lateral roots threaded their way through the root systems of adjacent plants to similar distances (29).

The next step was a demonstration of the fact that if such excavations were made in the winter, after the water-table had completed its autumnal rise and had fallen again, and provided that this rise had caused the immersion of the lower part of the root system, then those portions which had been covered by the rising water were found to be dead, though the remaining parts of the root were alive and producing an abundant growth of new roots; these latter passed downwards, and were reoccupying the layer of soil which had been invaded and evacuated again by the water (C.P.E. Figs. 30 and 35).

Another line of inquiry, based on the methods we shall describe in the next section, brought to light a remarkable series of phenomena which we termed "Functional Root-Interference."

At a certain stage in the growth of the field of cotton, the root systems of adjacent plants begin to interfere with one another's function; the time at which this interference takes place can be ascertained to within a day or so by the behaviour of the plants; this necessarily depends on the distance apart at which the plants are spaced, and on the geometrical arrangement of that spacing (A.A.Y. I.).

The effects of this interference are of great economic importance, since they lead to restriction in the water-supply of the plant, taking place at the hottest part of the growing season, and so necessitating very careful control of the water-supply given by irrigation, failing which more or less damage to the plants is caused.

One of the most striking things in this connection is the fact that the Egyptian native cultivator has for decades past pursued the custom of crowding his plants very closely on the available area, at the spacing already stated. For this he has been reproached by numerous reformers of excellent intention, who have pointed out that the United States employed far wider spacing, and they asserted that the Fellah was merely greedy, and was trying to get too much crop from his land. However, when we had completed our analysis of this root problem, we had incidentally shown beyond cavil that the native custom exactly balanced the two opposed causes—namely, gain in crop through having more productive plant-units upon a given area, and loss in crop through root interference.

Further than this, while our researches were being concluded, certain investigators in the United States who had spent some time in Egypt, advocated the application of a closer spacing in the States, with such successful agricultural results that the American cotton-growers are rapidly adopting the Egyptian system, and are thereby obtaining 30 per cent. more crop from their area, and an early crop into the bargain, at no extra cost.

Continuing these studies of the influence of environment upon the behaviour of the crop in the field, aided by the increasing detail and precision of our methods for recording not only the movement of the water-table, but also the water-content of soil above the saturated layer, we arrived at further conclusions.

In respect of soil-water proper we were able to show (37) that by August a cotton crop was drawing almost all its water-supply from a depth of a metre below the surface, at a rate of 50 tons per acre per day, whereas practically none was taken from the surface layers (R.C. Fig. 7). With regard to the water-table, we

were able in 1913 to trace most complex inter-relations between the movements of the water-table in different parts of a thirty-acre field, and to show that, so far from being stagnant, the water-table was continually pulsating under the influence of surface waterings and of changes in the levels of canals, at distances varying from a few yards to some miles away (38). Most of these phenomena had already been demonstrated by other workers since the initiation of the water-table controversy, and we merely added a final demonstration. More important, however, was the effect of this water-table in its big autumnal rise, which takes place as a consequence of the rise of the Nile flood, modified by irrigation practice.

In the year 1909, collaborating with our colleague Mr. Hughes, a "Terrace Experiment" was laid out in the hope that we could detect the effect of the water-table as it rose, by immersing on different dates the roots of the plants which grew on the various terraces; at the same time it seemed that this result had not been demonstrated, owing to accidental circumstances, and not until 1914 were we able to show that these 1909 data had concealed a convincing proof of our hypothesis (A.A.Y. III., Figs. 3 and 14). In 1911 the Survey Department's "Strip Experiment," laid out on a long strip of land which possessed a sloping water-table, showed definitely that the yield was directly proportional to the depth of available soil, but again we had to wait until 1914 for sufficient understanding to demonstrate from the data thus obtained that proof had also then been given as to the injurious effect of a rising water-table (A.A.Y. III., Fig. 15).

Subsequent experiments by the Survey Department staff (particularly Messrs. Ferrar, Hughes and Hurst), as well as by the author, together with the continued studies of M. Audebeau, extended our knowledge in various details, so that at the conclusion of the author's contract with the Egyptian Government, convincing proof was available that a rise in water-table amounting merely to an immersion of 20 centimetres of the root system, would produce permanently injurious effects upon the plants above (A.A.Y. III., Fig. 15).

To summarise the results of these root observations, it would seem that the functional root-system of the cotton plant in field crop might almost be likened to a sweep's brush, driving steadily downwards through the soil, and functional, so far as absorption is concerned, only at the lower end. Any interference with this brush is dangerous.

Graphs of Crop Development.

The phenomena of root-function described in the preceding chapter were, in the majority of cases, not observed directly. It is obvious that a root cannot be taken out from a depth of two metres below the surface, examined, replaced, and then expected to resume its behaviour as if nothing had happened. Practically all these phenomena had to be deduced from the behaviour of the stems of the plants above, and in this connection it may be advisable to add that the root-system, although invisible, constitutes exactly one-half of any plant.

The formation of these deductions was only made possible by our possession of an enormous mass of statistical information which had been obtained by means of a system of Plant Observation devised by the author, and can be presented for study in the form of Curves of Plant Development (A.A.Y. I.-III., etc.).

This system was adopted first by our collaborators in the Survey Department, subsequently by workers on cotton in the Sudan, in the Egyptian Ministry of Agriculture, and later in the West Indies; it is now being extended to the study of various other crops, both at home and on the Continent.

Its utility is such that anyone who has been using these graphs habitually for a year feels entirely at a loss when presented with the results of agricultural experiments in the usual form of expression, namely, the total yield produced; inspection of figures for total yield then produces exactly the same effect of irritation as would an attempt to make use of a dictionary from which most of the leaves had been torn.

In the first instance, the method is based on the statistical study of yields from small plots, which was developed by such workers as Wood, Stratton, Hall, Russell, and Udny Yule, and the publication of Wood and Stratton's first paper reached the author at a time when he had already developed, for purposes of research in cotton-breeding, a system of record for the height, daily flowering, and fruiting of individual plants (15). It needed only one step further to combine the two systems, and from this combination to develop a method of really extraordinary precision.

The basic idea underlying this method was to treat the cotton crop as an average plant multiplied many thousandfold.

Equally important with this was the idea of arranging for the records which show the behaviour of this average plant to be as nearly continuous throughout the season as limitations will permit. We avoided most of the limita-

tions by training ordinary Egyptian native labourers to take daily certain simple observations; these consisted mainly in counting the flowers or fruits, under an arrangement whereby the accuracy of the counts made by each plant observer became self-checking. This was, in fact, an early development of the principle of dilution of labour.

The only remaining difficulty was to obtain a true sampling of the plot, field, province, or country occupied by the cotton plants, so that the statistics might truly portray the average plants concerned. To secure this true sampling entails no especial difficulty since, given certain statistical constants determined by past experience, one can at the beginning of the season lay out as many observation groups each of 200 plants in as many places as may be needed to bring the result to any required degree of accuracy.

It may be added that, if this preliminary arrangement is done carelessly or stupidly, so that nominally comparable groups are not comparable, or so that the sample of plants observed is not a true sample, all the rest of the labour and time expended on these observations is wasted; there is some indication that this has been overlooked in certain recent agricultural publications.

During 1912 and 1913, with seven years' experience of the cotton plant in Egypt behind us, with this system of crop observations in full swing in two or three places besides our experiment station at Giza, and with these curves of crop development growing day by day along millimetre-squared paper on the laboratory walls, we gathered in data and conclusions, both of scientific and of practical importance, almost more rapidly than we could assimilate them. Indeed, it took the best part of two years' desk work at Cambridge subsequently to present them in publishable form, and even so the data published only related to environmental effects, the whole of our genetics data since 1911 being still untouched.

The scientific results obtained were largely concerned with root-function, also with the effect of excessive temperatures upon growth (R.C. Fig. 4)—and this alone suggests sufficient laboratory experimental work for several years' occupation—the permeability of protoplasm in relation to temperature (A.A.Y. II.) (since subsequently and independently worked out by Miss Delf), and many other minor points.

More important than any of these, however, was the statistical recognition and analysis of a phenomenon which we designated by the awkward title of "Pre-Determination" (A.A.Y. III.). This phenomenon is a commonplace of biology, in the sense that hyacinth bulbs raised in Holland pre-determine a better show of bloom than those raised in England, and so forth; but we were able, through our accumulated data, to show that it is a factor which ought to be taken into account at every turn in analysing the effects upon the growing plant of the "limiting factors" of the environment, and it is probably no exaggeration to say that the recognition of this factor will markedly accelerate our progress in the study of living plants growing under the conditions of the open field.

Without discussing this law of pre-determination in detail, we may advert to one of its economic consequences, which is this—

That by making appropriate observations at one stage of the life of an average plant (that is to say, of a crop), we can *forecast* what that crop will do at a later stage; the interval between the original observation and the actual manifestation of its sequel may, in the case of cotton, be as much as ten weeks in length (A.A.Y. III., Figs. 10, 11, 17). Thus, at the end of May 1913, the author was able to forecast, quite against accepted opinion at the time, that cotton would probably arrive in Alexandria during September in greater quantities than it had done for many years past (R.C. Fig. 10).

Confining ourselves to the simpler forecasts, based merely on observations of the rate of flowering of the crop, it should be a comparatively easy matter to effect this for the whole of Egypt, or indeed for any other country, by means of a suitable scattering of observation stations throughout the country concerned.

These observing stations would consist of about ten groups of two hundred plants, each chosen at random in the field of some farmer, who was willing that the observer should visit and observe these groups day by day during the season in order to count the flowers as they opened and the bolls as they ripened. With some fifty such stations scattered about Egypt and reporting the statistical results of their observations, either by postcard or by telegraph, every day to the central station, it would then be a simple matter to prepare and issue graphs showing the development of the cotton crop for the whole country and for particular districts, with organisation exactly similar to that of a weather bureau.

We began an attempt to persuade the Egyptian Agricultural Service to create such a system of precision crop reports, in place of the subjective

and uncertain system based on personal estimates universally employed, but without success. Nevertheless, we venture to think it more than probable that some system of this kind, based firstly on statistical methods of sampling, secondly on the observations of the average plant, and, thirdly, presented and circulated in the form of graphs running completely through the season, will, before many years have elapsed, be adopted for the more important agricultural crops in several countries.

There is one development of this method which is extraordinarily interesting, since it enables us to deduce approximately the form of the fruiting curve for the Egyptian cotton crop during seasons preceding the establishment of direct observations, and although the deduced curves have not the same absolute value as those which we hope to see year by year in the future, they are not without interest, especially in connection with the water-table hypothesis. The available data for their deduction are those for the arrival of cotton at Alexandria, which is the place of export for almost every bale of cotton grown in Egypt.

The ginning factories in the interior of Egypt start work as soon as the picking of the crop commences in each year, and they work at high pressure until the ginning is completed; the first lots of cotton ginned in each season are despatched to Alexandria immediately, the later ones may be held up more or less, according to conditions of market price, transport, etc., with the result that an appreciable amount of cotton may still be coming down to Alexandria as late as thirty weeks after the season commences.

The statistics kept by the Alexandria General Produce Association for these arrivals week by week, have been studied by various people, notably Messrs. Craig and Orenstein, and it has been noticed that the date of average arrivals has shifted backwards during the last decade or so—in other words, the bulk of the crop reaches Alexandria sooner than it used to do. We had always been under the impression that the effect of variations of price, transport, and the like had an overwhelming influence on the rates of arrival, but it occurred to the author after leaving Egypt, that it was just possible that the actual rate of ripening of the crop in the field might be a contributory factor in the rate of arrival at Alexandria. This had indeed long been known to be the case in the matter of the first cotton of the season, but since the bolling curve (which represents the daily rate of ripening of the boll) occupies a period of only two months, whereas the arrivals at Alexandria spread over a period of twenty-five weeks or more (*slide unpublished*), it was clear that whatever effect the first curve had upon the second must be tremendously distorted in time (Preliminary Note in A.A.Y. III., p. 206).

However, we proceeded to turn the arrival figures for each year, from 1898 to date, into comparable form: in the first place, we calculated the arrivals for each week in terms of a single acre from the known total acreage of each season so as to eliminate variations in the area cultivated year by year, and then we calculated the five-week means in order to remove small fluctuations due to public holidays, temporary alterations of price, and the like. Having thus obtained a series of smooth and comparable curves, several interesting facts came to light when these were matched against the statistics for change of price, etc.

The first fact was that, with the exception of only three years in the series, the changes of price appeared to be without any marked effect on the general form of the smoothed curve. In the second place, we found that a simple graphic device allowed one to turn these graphs into something not very remotely resembling a bolling curve. This device merely consisted in the compression of the ordinates for successive weeks by a logarithmic scale, in this way compensating for the slowing down of arrivals which takes place each year as the market becomes full of cotton.

For the season 1909–1913 we possessed precise data from a few sites showing what the form of the bolling curve had been for these places, and by 1913 we understood the causes affecting the forms of these curves sufficiently to be able to draw the probable form of the curve for the whole country. Putting the bolling curves for these five years side by side with the arrivals curves as plotted on logarithm paper, it was immediately obvious that all the salient features of these curves—their rise, their maximum, and their fall—were identical in both cases (*slide unpublished*). We then carried our inquiry backward by examining the available agricultural information concerning the general behaviour of the crops in preceding years, graphed these roughly in the form of bolling curves, and found that they also agreed very well with the arrival curves. Since 1915, comparisons have also been made with the crops produced to date, and there seems to be very little doubt that in spite of all the disturbing causes which might be expected to operate on the rate of arrival at Alexandria, the principal determinant for the form of the arrival curve is the *actual rate of ripening of the cotton* in the field, and that in consequence the Alexandria arrivals give us a first approximation to the form of the bolling curves.

Now the importance of this speculation—though indeed it is something more than a mere speculation—need scarcely be emphasised in connection with our interpretation of the falling-off in yield of recent years as being chiefly due to water-logging.

Assuming that the bolling curve of bygone crops has thus been restored to us by the Alexandria data, we find that the maximum height of the curve, which is an index to the chemical and physical fertility of the soil, has been as great in 1910 and 1913 as it was at the "high-water mark" period around 1898 (*slide unpublished*). We find further, that the curve rises no sooner and no later than it used to do in the past, so that the crop is not deteriorating in that respect either; some years are merely

exceptionally early, others late. In these respects the last few years have been exceptionally interesting. These, however, are trivial and comparatively familiar facts in comparison with the way in which the arrival curve is seen to fall off, when its tail-portion has been compressed by the use of logarithmic abscissæ.

If we except the price-effect in 1904 and 1907, it is quite obvious that the curve is cut off in exactly the same way that the bolling curve or flowering curve is cut off by a rise in the water-table, and the date at which this cutting-off begins has been coming steadily earlier since 1898. A line drawn to represent the cutting-off effect, *i.e.* a smoothing of this part of the curve to a straight line, intersects the base line in 1898 at the thirty-eighth week of the season, as against the twenty-sixth week in 1909 and in 1916.

Thus it would appear that all other things are equal to what they were in the past under similar conditions. The crop is not earlier or later, and the land under favourable conditions of summer water attains to nearly as high a rate of production per acre, but the enormous difference is this—

That whereas in 1899 the maximum rate of production was maintained during a period corresponding to eight weeks of arrivals at Alexandria, it is now maintained on the average for a much shorter period, and even (in the case of such years as 1909, 1916, and 1915) is scarcely reached at all before the cutting-off effect, caused by the rise of the water-table, makes its appearance.

This is exactly in accordance with what research since 1906 has shown about the change in the subsoil water conditions of the country. Evidence from various sources, such as well levels, troubles by seepage of water into the walls of subways and cellars, and the like, shows that the water-table of the country as a whole has been raised nearer the surface to the extent of some two metres as compared with its level in the past, in all the "terres perméables" of the country.

During the greater part of the year this does not matter much, but in the old days a high and early flood had to raise the level of the water-table a considerable distance before the water could reach the roots of the plants. Nowadays, the roots of the plants are, as a rule, already in contact with the water-table when the flood comes down (A.A.Y. III.). Consequently identical floods nowadays cut off the bolling curve some two or perhaps three weeks sooner than they did in the past, and the time of rise of the water-table year by year has reflected itself sooner and sooner in the time of falling-off of arrivals at Alexandria.

The words "time of rise of the water-table" are used advisedly, since this is not the same thing altogether as the time of arrival of the flood; although the former is dependent on the latter, it is capable of control to an appreciable extent by the Irrigation Department, and now that the department recognises the importance of so doing, we find such gratifying results as this: That although the 1917 flood was far worse from this point of view than the flood of 1909, its effects were actually delayed two weeks (on the arrival curves) as compared with the effects of 1909. At the same time, this is not the limit of the control which will be exerted when the yield per acre in Egypt has been restored to its old level, as may be seen from the following figures:—The cutting off of the arrival curve for recent crops has taken place seven weeks sooner than in 1898 or 1899, with the consequent dead loss to the country of some 200,000,000 lb. of cotton, worth at present prices, the colossal sum of twenty million pounds per annum.

The critic may ask why we have neglected the effects of the pink boll-worm in our discussion so far, and the answer is that in spite of the ravages of this new pest from 1913 onwards, the water-table effects are still the most conspicuous feature of the arrival curves. The year 1913 is particularly striking, and shows even more damage due to boll-worm than any subsequent year, because its flood was very late, the latest for a century; the cutting off of the curve by the flood is only just visible towards the end of the season, whereas the fall of the curve takes place at a strange angle and in an unusual way, which can only be attributed to the very bad attack of the pink boll-worm. A minor exemplification of the same effect may be seen on examination of the curve for 1905, which was a bad year for the ordinary boll-worm. After 1913 the arrivals of the crop were disturbed by the war and it is scarcely legitimate to discuss them, but they indicate clearly that the pink boll-worm has not again caused anything like the same amount of loss as in 1913; the small crops obtained have been due to water-table effects in the first instance, and the boll-worm has been unfairly saddled with the responsibility for the whole of this loss.

It must not be thought that this new boll-worm is not a serious pest of the Egyptian crop. It is a most important factor in the situation, especially in affecting quality, and it is remarkable that it should have been able to play havoc with the crop as it did in 1913, when it had only lived in Egypt for some four years, but the outstanding thing is the contrast between the arrival curves of 1898 and 1899, and those of the last decade, when read in the light of this new interpretation.

The foresight of Sir Colin Scott Moncreiff, the founder of the Egyptian Irrigation Service, has been fully justified by events; from the outset of his great work he insisted on the equivalence of drainage with irrigation. Under his successors the former function of the service was not developed and studied to the extent Sir Colin had advised, and the reformation now in course of development under Sir Murdoch Macdonald must necessarily take many years' hard work, study, and productive expenditure before the efficiency of Egyptian soil can be, for the deep-rooted summer crops, brought back to the level at which it might conceivably have been maintained during the past twenty years, had systematic experiment and research been recognised in the interim as being an inevitable concomitant to reconstruction of the State.

Conclusion.

Glancing back over the material discussed in this paper, we may note how utterly impossible it is to demarcate applied science from pure science, as is so frequently attempted. We have pointed out in some places how an investigation begun for strictly economic purposes has shown the existence of great gaps in our knowledge of scientific phenomena, which gaps were filled up automatically in order to complete the economic inquiries. Conversely, inquiries begun with a scientific object simply to strengthen the foundations of our knowledge about the cotton plant, have quite unexpectedly produced results of economic significance. In research of this kind there can be no distinction between pure and applied science; it may be called "pure" because its conduct is guided by the professional methods and etiquette of natural science, or it may be called "applied" because whatever subject may be under investigation, the material is provided by a plant which represents economic values. It is really quite immaterial what we call it, for substantially it is in intention and execution strictly scientific work carried out on an economic material.

One other curious feature of these researches is the rich diversity of subjects they include, of which we have only mentioned a few to-day. This is partly due to the fact that the work was done under circumstances which did not permit of relegating particular problems to specialists to any great extent; partly because such researches are continually infringing on all branches of knowledge, their centripetal whirl taking place round a subject which passes through every range of human interest from Egyptology to engineering.

But throughout this intricate tangle of interesting topics there was always a pattern growing, more visible to the author perhaps than to anybody else, but scarcely capable of definite explanation until the work had been discontinued. Our Chairman once reviewed a book published by the author at a stage when it was not safe to prophecy how the finished pattern would appear, and he made the sole objection to it that the "Cotton Plant" was not a subject upon which a book should legitimately be written. There is justice and some small revenge in his presence here to-day.

Those of us who have tried to develop the plant industries, realise, as few of us can realise, how small and struggling is the study of the living plant to-day, and yet how it will affect the civilisation of the states of the world tomorrow. Even the "man in the street" now realises faintly the totality of his ultimate dependence on plants for his food and his life, and there is hope that this realisation may serve to lift the science of botany from its preoccupation with dead things. To such leaders as Bateson and F. F. Blackman, who have organised clear thought in place of turbid speculation—the one for the plant, the other for its environment—that future will stand permanently indebted.

DISCUSSION.

The Chairman (Professor William Bateson) said that he hoped they would share the enthusiasm he himself had felt in listening to the paper. He said at the opening that science had scarcely been applied at all to tropical plants and sub-tropical plants, and when one considered the nature of these wide problems one realised how impossible it was to separate pure science and applied science. Let them think of the question of the water-table alone, which Dr. Balls had discussed. One might make graphs of the depth of water, the cotton produced, and suspect the relation of cause to effect, but to be really certain one must have considerable acquaintance with the physiology of plants. He shared with Dr. Balls the love of graphs. To show graphs of every stage in the formation of bolls was, he thought, an example of a new method of studying plants. They would see at once, when things were set out in that way, with what they were dealing. He hoped the study was one which would be very largely extended.

Professor J. A. Todd said that he had had the privilege of being associated with Dr. Balls in Egypt, and he thought that he had learnt enough about his work to know how little he (the speaker) really knew of the subject. His side of the matter was economic entirely. He was particularly interested in the machine which Dr. Balls had invented, because that had a definite economic bearing. The cotton crop had been falling off during the last year, and looked like sticking at a particular total when the Government decided to buy the Egyptian crop at a fixed price, and the result was that the "arrivals" at Alexandria had taken an unprecedented jump. The cotton was coming in because the price was fixed. He would like to add his personal appreciation of the work that Dr. Balls had done. It had been an extraordinary pleasure to see one of the results in the machine. It was as remarkable from a mechanical point of view as it was from a purely scientific.

Mr. C. F. Cross said they had listened to an entirely stimulating address on a subject of enormous importance which, through the *Journal*, would be made known to a wider circle than the present audience. Cotton was the basis of a large portion of our economic and industrial system. He hoped they would be able to impress on politicians and Government to see to it that, so far as depended on them, the lead we had in this country was maintained. It could only be done in one way; by accepting the whole gospel of science in the matter, and addressing themselves to the subject as intellectuals.

On the motion of the Chairman, a vote of thanks was accorded to Dr. Balls for his interesting paper, and the meeting terminated.

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***All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.* (2)**

PROCEEDINGS OF THE SOCIETY.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 17th, 1918; J. AUGUSTUS VOELCKER, M.A., Ph.D., Member of the Council of the Society, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Burley, Sydney Waterlow, Sittingbourne, Kent.
Kendrick, A. F., London.
Lawrey, William, Penzance.
Newman, James Harold, London.
Oliver, William Grant, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Heine, William M., Connecticut, U.S.A.
Malcolm, George William, London.
Stobie, Victor, Gosforth, Northumberland.
Strachan, Robert Price, Bristol.
Weir, John Cunningham, London.

The paper read was—

AGRICULTURAL MACHINERY.

By FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England.

For many years before the outbreak of the present war, the agricultural industry suffered from a serious shortage of labour, and unfortunately the general publio took very little interest in the industry, partly from the fact that it is one carried on unostentatiously away from the great centres of population; moreover, so long as he can obtain the necessaries of life at a reasonable cost, the average man cares little whether they are produced at home, or, as has been the case with us in an increasing degree, imported—as to cereals up to four-fifths and as to meat to one-half of our requirements.

Agriculture, however, is the most important industry of this or any other country, and it should never be forgotten that it is one which requires as much skill and training as any of those other industries which figure more prominently in the public eye.

The crisis through which this country has passed during the last three and a half years, the realisation of the shortage of home food production, the peril of the submarine, and the indefiniteness of the duration of the war, have to a great extent dispelled this apathy and have awakened a keener interest about agricultural matters.

From the very important part which agriculture in this country has held—though scantily recognised either by Government or the general public, until present war exigencies forced it into prominence—it is but natural that with the advance made in industries generally, and in the processes connected with them, there should be a similar advance in the practice and use of implements connected with agriculture.

The state of efficiency to which such implements and machinery have attained might tempt one to a retrospect, to trace the origin of the machines and to follow their subsequent gradual development. Such a study, however, is quite beyond the scope of one paper. It is well known to all that such implements as the plough, or the methods of thrashing corn, are of the remotest antiquity, and it is evident from old carvings and illustrations that for centuries very little progress was made in their development. This fact is also substantiated by the crudeness of the methods and of the implements in use at the present day in some countries. During the last century and a half there has been a remarkable development, so much so that there is now hardly a process in agriculture to which mechanical science has not been applied.

When the Society of Arts was founded in 1754, it is recorded that "the implements then

available for the farmers' use were very few and of a very inferior sort." The plough and harrow were in use, but the hay and corn harvests were cut by hand with scythe and sickle, and the corn was thrashed by the flail. The Society at once directed its energies to the encouragement of agriculture, and for a long series of years, by means of awards and trials, successfully stimulated the development of agricultural implements, at the same time also furthering improved methods of agriculture generally; and this work it carried on regularly until 1838, when the Royal Agricultural Society of England was formed, and it became the representative society of British agriculture. It at once established a system of holding annual agricultural shows throughout the kingdom, where agriculturists and manufacturers had the opportunity of meeting and of exchanging opinions, and, following the example of the parent society, it offered awards and conducted trials of such new machines as presented themselves. These awards unquestionably gave a great stimulus to production and development of various implements. The agriculturist then had little or no experience with mechanical contrivances, and the award gave him a certain amount of confidence in the new implement and thus assured the manufacturer of a market. It must be remembered further, that at that time advertisement had not been raised to its present day "high art."

For the first few years after the foundation of the Royal Agricultural Society, trials of all new implements as they appeared were made each year. Later, however, when agricultural machinery had fairly established itself, and the agriculturist had recognised its advantage, conditions became materially altered, and it was found unnecessary and undesirable to have repeated competitions of the same class of machinery which might have become very unfair and harassing for the exhibitors, as well as misleading to prospective purchasers. It must be borne in mind that the manufacturer and the consumer do not always quite look eye to eye on the question of trials. The former may be over anxious to know the effect of any slight modification made in a machine, while the latter may very fairly resent having a competition—in which perhaps he has been successful—repeated because some other competitor may have made modification in his machine for which he claims great merit. Both arguments require, and have received, careful consideration.

Changes in the intervals of trials were made from time to time, and the system adopted of late years is, first, to decide what class of machinery is most in demand at the time by agriculturists, whether it be the improvement of existing machines or the introduction and development of new ones. Regulations are then drawn up, setting out the special features or improvements aimed at and the conditions under which the trials will be conducted. Such information is sent to the several manufacturers about twelve months before the trials, so as to enable them thoroughly to prepare and test their machines beforehand, and also enabling the engineering staff of the Society to make all necessary preparations for carrying out the trials and making them as thorough as possible. In practice this method has been found to work satisfactorily.

Agricultural implements have been conveniently classified into two groups:—

(*a*) Those for preparing the land for the crop and for sowing or planting the crop, which includes the various forms of ploughs, cultivators, rollers, seed drills, potato planters, etc.; (*b*) those for gaining the crop and preparing it either for market or for consumption on the farm, such as mowing and reaping machines, haymakers, thrashing machines with trussers and elevators, hay and straw presses, chaff cutters, grist mills, etc. This classification was complete so long as the several processes were carried out by horse-power. Now, however, we have to consider the question of prime movers in the various forms, whether steam or oil engines, water, wind, or electric power, in conjunction with the machine.

The Plough.

As no one can dispute the very ancient lineage of the plough, I shall not attempt to trace its early history. In 1773 Brand, a Suffolk blacksmith, is reported to have made the first plough, in which the frame was mainly of iron, and it would appear that even then great care was expended on the curve of the breast, so as to turn over a neat rectangular strip of soil, completely burying the growth on its upper surface. This resulted in the gradual lengthening of the breast.

As early as 1785 Robert Ransome, the founder of the well-known Ipswich firm, patented a process for tempering shares made of cast-iron, and in 1803 he took out a patent for "chilling" the under side of cast-iron shares, which previously rapidly became blunt with wear. In 1852 Mr. James Howard patented the chilling

of the breast of the plough. These two developments constitute certainly the most important phases in the construction of the plough.

The application of a wheel or pair of wheels to reduce the work on the man working the plough, as well as to reduce its draught, was first shown in this country in connection with an iron-framed plough at the Royal Agricultural Society by Mr. John Howard. The principle, however, was not new.

The double-furrow plough—though apparently used in a crude form in the time of the Commonwealth—was developed about 1802 by Lord Sommerville, who took out a patent for it, and did much towards its introduction. It was subsequently much improved upon by Mr. Thomas Pirrie (1867), who introduced a friction wheel behind the plough in the angle of the furrow, in place of the slade, to reduce the draught. A three-furrow plough was invented by the Rev. Dr. Cartwright, for which he received a medal from this Society, in the description of which he pertinently describes the advantage to be obtained by a multiple plough, thus: "In a single plough a certain length and width are required in those parts of it to make it go steady . . . when two, three, or more ploughs are combined, they serve to steady each other." The friction on the land side of the plough is also materially diminished. For some few years the double-furrow plough was fairly used, but it fell into disuse for some reason or other until the last twenty or twenty-five years.

The types of ploughs with their varying forms of shares and breasts are now numberless, and it is difficult to get any general agreement as to the merits of each, so much has old custom and use to do with the selection of any one type, as evidenced by the differing types used in the several counties. With the view of obtaining a uniform unbroken furrow, and also of reducing the draught, the length of breast was increased with a more gradual incline. Now, however, the tendency is to shorten the body of the plough and make the breasts approximate more to the digging breasts.

On the question of comparative draught, I can but quote in brief my remarks in the report of ploughing trials at Warwick by the Royal Agricultural Society in 1892, "unless you have precisely similar conditions of the trials and soil, both as regards the nature of the soil and its moisture, comparisons may be very misleading."

The diagram on the screen shows what difference of draught there may be between two fields on one farm. The mean draught in one case with a three-furrow plough being 7 cwt. on the draw bar, and in the other case 44 cwt., with similar plough.

The area which might be ploughed with a single-furrow plough must be controlled by the rate at which a man can walk behind it throughout the day. This is found not to exceed two miles per hour, which with a furrow 10 in. wide, and allowing a slight margin for turning at the ends of the furrow, gives 1·3 acres in eight hours. Anything which accelerates this rate of work is of the greatest advantage, it being of the very first importance to get the ploughing done in suitable weather. The farmer, therefore, was ready to welcome the application of the steam engine to expedite the work.

As early as 1866–67 an inquiry was made by the Royal Agricultural Society on the subject of steam cultivation, and a most interesting report gives details of the work done and comparative costs of it for the period 1858 to 1865, the average amount of work done being at the rate of six acres per diem. Direct haulage of the plough by the engine was tried as early as 1865, but objection was taken to the weight of the engine, traversing and compressing the land, and this method was for the time abandoned.

In 1870 the Royal Agricultural Society arranged for a competition of steam ploughing-plant to be held in connection with its Wolverhampton show in 1871. There was a large number of competitors, and the several systems then in vogue were duly represented. The results of these trials were of a most conclusive nature, and are fully reported in Vol. VII. (1871) of the Society's *Journal*. The adaptability of mechanical haulage to ploughing was conclusively demonstrated, and of the several systems, such as: (*a*) The double-engine system, with an engine at opposite sides of the field hauling the plough backwards and forwards between them by means of a wire rope; (*b*) the single-winding engine with travelling (Campain's) anchor on opposite headland; (*c*) the roundabout system, in which a portable engine drove direct by means of a "Hooks" coupling rod, a double windlass, the ropes from which were guided by grooved pulleys at the corner of the space to be ploughed; (*d*) the high-speed roundabout rope system of Mr. Fisken.

The double-engine system proved its pre-eminence for getting through the work efficiently in any case where the fields are of moderate or large size.

The travelling anchor system was not so

satisfactory. Difficulties and delays arise with the travelling anchor, which would be emphasised were the ground soft.

The roundabout system, I remember, appealed to many, as being specially applicable to small holdings where the farmer was already in possession of a portable engine. It, however, entailed a very undue amount of attendance, especially in setting to work.

The comment of the owner of one of such sets, who wanted to replace it by a double engine set, to the effect that "it did its work well, but remains too long in one field," precisely summarises the position.

The high-speed rope tackle was an interesting application to ploughing of the high-speed rope drive as used for working travelling cranes in engineering works. It consisted of an ordinary portable engine having a groove turned in the fly-wheel to carry the driving rope, which encircled the field, and communicated motion to the hauling gear of the plough. One great claim of the inventor was that the engine need not be taken into the field, but may be placed in any neighbouring position close to a water-supply and convenient for delivery of coal. Such advantage was more than outweighed by the very excessive attendance and wear and tear involved, in addition to which there was frequent trouble with the slackening and tightening of the rope with any change of weather.

Of all the systems the one which has maintained its position is the double-engine system, which, for efficiently getting through a large amount of work is still pre-eminent. I am enabled to state on the authority of one of the leading steam-plough makers that of approximately 540 sets of double engines sets (similar to those tried at Wolverhampton) at work in this country, 267 are over forty years old, 99 between thirty and forty years old, 13 between twenty and thirty years old, 28 between ten and twenty years old, and 133 under ten years old.

With the advent of the oil tractor a new condition was created, and in 1897, at Manchester, prizes were offered for the best agricultural tractor. Only one, however, presented itself, and it failed to complete its trial. The following year, 1898, at Birmingham, prizes were offered of £100 and £50 for vehicles to carry up to one ton and similar prizes for vehicles to carry three tons. In the result, only one prize in each class was awarded.

The diminished weight of the oil tractor led to a material modification of former views with regard to the direct haulage of a plough or cultivator. Consequently the Society offered prizes for a competition in 1910 of the best agricultural tractor (steam or oil) suitable for direct haulage of cultivating or harvesting machinery, and to be also suitable for road traction or driving a thrashing machine or other farm machinery. Seven machines were entered —three steam engines and four oil tractors. In the result the best and most economical work was done by the steam tractor. The oil tractors, however, showed clearly that with further development they would give very different results. Their design and also workmanship were crude, and from want of experience the competitors expected too much of them, and gave them too heavy a task to perform. In these trials the weights of the several motors varied from two tons to six tons, and they were all tried on similar plots of five acres in the same field, and it is interesting to note that no appreciable difference could be distinguished in the succeeding crop, and, as further evidence that no harm was done, I may say that the farmer has now had two motor tractors at work on his farm for some time, and has a motor plough on order, in addition to them. I have not been able to collect any such positive evidence in the opposite direction as to the injury done by a given weight travelling over the ground in compressing the soil. Since the date of these trials the development of the motor tractor has surpassed that of any other agricultural machine, whether it be in its variety of designs or the number of manufacturers in this country and America who have taken it up.

A most interesting and instructive paper, entitled "Traction on Bad Roads or Land," was read in January last by Mr. Legros before the Institution of Mechanical Engineers, and published in the Institution *Proceedings*, which gives a very careful and comprehensive description of motor tractors, and to which I would refer any one wishing to inquire further in the matter.

Previous to the outbreak of the war, the Royal Agricultural Society had decided to hold further trials of agricultural tractors in 1915, the conditions and regulations having been published and circularised in July 1914. Unfortunately the war necessitated their postponement. In the meantime, however, much valuable experience is being gained at the war front, where the caterpillar system of the tanks has

accomplished so much success and attracted so much attention, and has been taken up by several of the leading manufacturers, as well as in the use of the several types of tractors in this country ploughing up the additional area of land required. It will be then for the manufacturers to evolve a general utility machine for agricultural purposes, which will of necessity vary somewhat from what may have proved itself best for either of the above purposes. The proposed trials for 1915 have only been postponed, and it is the intention of the Society, so soon as a normal condition is resumed, and the manufacturers have had time to make the necessary preparations, that they shall take place. After careful consideration, prizes were offered for four classes, viz. :—

Class I.—Direct internal-combustion plant of 20 b.h.p., to plough not more than four furrows, 9 in. wide by 6 in. deep.

Class II.—Direct internal-combustion plant over 20 b.h.p., or steam ploughing outfit suitable for ploughing not more than six furrows, 10 in. wide by 8 in. deep.

Class III.—Self-propelled plough turning not more than four furrows, 9 in. wide by 6 in. deep.

Class IV.—Plough suitable for direct tractor work, turning not more than six furrows.

1. For the purpose of such trials an "agricultural tractor" shall be capable of: (*a*) Hauling direct in work, a plough, cultivator, harvester, or other agricultural implement; (*b*) driving barn machinery; (*c*) hauling a load along a road and on the land.

2. The machines shall be tested for efficiency in carrying out all classes of work. The following are some of the points to which special attention is directed: (*a*) Weight of machine; (*b*) weight per inch width of wheel; (*c*) mechanical design and construction; (*d*) adaptability to various kinds of work, such as harvesting and the like; (*e*) ease and safety of handling; (*f*) ease of turning and space required for same; (*g*) efficiency of winding gear; (*h*) facility of attachment; (*i*) attendance necessary; (*j*) consumption of fuel, water, and other supplies per unit of work done; (*k*) price.

Bearing on these, I might mention, under the heading of "Ease of Turning," that most motor tractors with a plough behind them do leave an unduly wide headland, and that the frequent passage of the motor along the headland each time it turns may unduly compress the soil, making it desirable that the plough and tractor should be as compact as possible. I know that this question was certainly recognised by some manufacturers who were working in the direction of getting over the difficulty until stopped by the exigencies of the war.

With the motor plough, in which the motor and plough form one combined machine, the width of headland is materially reduced, but there is a considerable loss of time in turning at the end of each series of furrows. From actual observation in ordinary work the mean time occupied in turning on the headland and getting into work cannot be put at less than one minute, and taking a field 500 yards wide, with the plough travelling at the rate of 3½ miles per hour, the time lost amounts to 20½ per cent. of the total time, increasing with a lessened length of furrow. This loss might be materially lessened by the adoption of a balanced plough, similar to that used with the double-engine steam sets. The cost of the motor and the plough would of necessity be increased, but the saving in time might well repay the extra outlay.

Work done: The speed at which it is desirable for the plough to travel requires definite consideration; whether it is better to travel at a high rate of speed with a two or three-furrow plough, or at a slower rate with a three or four-furrow plough. The motor, provided it is of sufficient power, will meet either case, but existing patterns of ploughs designed for a slow speed will not hold in the ground at a high speed, especially if they are working on a gravelly or stony bottom.

Attendance necessary is an exceedingly important point; it is most desirable with the inevitable shortage of labour to reduce the number of attendants to a minimum. Price is also a consideration, especially in the case of moderate-sized farms. There are other vexed questions, such as: Whether the tractor should have three or four wheels, and whether the driving wheels should run on the land side or in the furrow. If the latter course is to be adopted, the width of furrows must be increased to accommodate the width of the wheel. There is still a lack of uniformity in the diameter and width of wheels. Anything in the direction of approved simplification and standardisation is most desirable, and would prove of great advantage both to the manufacturer and the user.

Under the term of cultivator, I would include scarifiers and grubbers, one of which, Finlayson's grubber, patented in 1844, consisted of a frame carrying curved prongs mounted on three

wheels, the foremost running on a curved axle by which the frame may be raised or lowered on the wheel so as to put the prongs in and out of work. In this machine you have embodied the main design of the modern cultivator, which may be divided into three classes: (*a*) Rigid tine cultivators; (*b*) spring tine cultivators; (*c*) disc cultivators.

The cultivator generally follows the plough, though in some cases it is used for breaking up the land, especially when it is very hard, for which the rigid tine cultivator is used. Intermediate between the rigid tine and the spring tine cultivator is an implement which does very good work, in which the tines shaped like rigid tines are mounted on the frame through a steel spring connection. This gives a certain amount of play to the tine, and in the event of coming into very stiff land the tine comes up against a stop and acts as a rigid tine. The spring tine cultivator, introduced in the first instance from America, does good work after the ground has been broken by the plough, and prepares an excellent seed-bed. The disc cultivator consists of a series of steel discs mounted somewhat obliquely to the travel of the machine. The discs cut up the rough soil and rapidly reduce it to a fine bed. In its lighter forms it is used as a disc harrow. When these implements have to be used with a motor plough, they are so mounted on a frame as to be interchangeable with the plough, which would be removed from the motor.

Before leaving the implements for breaking up the land, I may call attention to some of the efforts made in mechanical digging. One of the first substitutes for a plough was a revolving cylinder with radial prongs or tines (1846), and by making the speed at which these revolved independent of the rate of travel of the machine, the ground was to a certain extent broken, and such a machine was reported in 1855 to do "its work most perfectly, leaving the land sufficiently pulverised to be quite ready to receive the seed." In hard ground, however, the tines of some of these rotary diggers revolving in the same direction as the travel of the machine, would not enter the ground. To get over this, in 1857 a machine was patented with the revolution of the tines in the opposite direction to that of progress; the tines having once opened a way enter the ground on the already broken surface. This action, however, caused the earth raised to be thrown over the axle of the tines, and could not be considered satisfactory.

At Carlisle, in the year 1880, Mr. Darby first exhibited his digger, where it was tried, and, though the ground was wet and very hilly, certainly did successful work, proving the practicability of mechanical digging. Its weight, however, was 15½ tons, which was excessive, and it was considered that the earth was not sufficiently broken up after having been submitted to so much compression. The accompanying slide conveys an idea of the plant. The next development of this system of digger was its adaptation to the rear of a traction engine, the digging forks being driven at a much higher speed than in the original Darby digger. This machine was tried at Leicester in 1896, and again at York in 1900, when prizes were offered for a competition of steam diggers. The work done was excellent, and the machine received an award on each occasion.

Other more recent diggers have not proved satisfactory, nor has the system of steam digging been taken up by the agriculturist.

Harrows.

The first idea of this was the primitive Bush harrow, which still does good work on grass land, and has developed into numerous types. The zigzag harrow with its rigid tines originated about 1839, and chain harrows—to take the place of Bush harrows—emanated from Smith of Doncaster about 1842.

Rollers.

It is unnecessary to comment much on these. The division of the wooden cylindrical roller into two lengths very materially facilitated its turning. The Cambridge roller, or ring roller, patented in 1841 by Crosshill, is of its class a most efficient machine. The manner in which the several rings are mounted on the main axle, allowing for a certain amount of play between them, enables the roller to adapt itself to irregularities of the surface and also prevents the soil clogging on the face of the rolls.

Seed Drills.

Next in order of machines comes seed drills, the special features of which are: (*a*) The precise regulation of the quantity sown per acre of any given seed; (*b*) the efficient planting and covering of the seed, regulated by the depth and angle of the coulter at the end of the delivery tube; (*c*) facility of steerage so that each bout of a machine may be kept actually parallel and equally spaced.

One of the earliest forms is the cup drill, which on fairly even ground gives a wonderfully

uniform delivery, and has done excellent work in all competitions. It is very generally adopted throughout Europe. Another form of drill consists of a long seed box, more or less triangular in section, with several holes pierced in the bottom leading to the delivery tubes, the delivery of the seed through these holes being regulated by either a revolving pinion or brush or by a revolving disc with an irregular flange, the recess in which would allow the seed to pass, while the projections close the apertures.

Potato Planters.

In connection with seed drills must be included the potato planter, which may be arranged for planting either one or two rows. The accompanying slide shows a single-row machine, consisting of a hopper mounted on travelling wheels, in which the tubers are placed. An endless chain fitted with small dredger-cups picks up the tubers from the hopper and delivers them down the delivery tube into the furrow.

Although out of order, I may here refer to the potato digger. The first machines of the kind consisted of a wide-shared plough with double flexible breast, formed of wrought-iron rods free to some extent to move. The share passed well under the tubers, the earth raised with the potatoes was sieved through the open breast and the tubers were delivered to each side. This did not collect the potatoes in a sufficiently limited area for collecting. The most approved form of machine now consists of a plough—as before—with a revolving wheel at the rear, with feathering tines or forks arranged round same. These separate the potatoes and deliver them gently in one row alongside the furrow. As a labour-saving machine it is most efficient.

Manure Distributors.

An equable distribution of manure over the land, both from the point of economy and of efficiency, is most important. For the distribution of farmyard manure, such distributors consist of a waggon with a travelling false bottom actuated by gearing from the travelling wheels of the waggon. Across the rear end of the cart is a spindle or drum with a series of pins fixed therein; this, actuated from the driving wheels of the cart, combs out the manure as it is fed up to it by the action of the travelling false bottom. So long as the manure is short and well rotted they work admirably, and I have met users of them, who, taking care that they should work under such conditions, have been fully satisfied with them, but if they have to deal with anything in the way of longish straw they choke hopelessly. There is, further, the drawback of the waste of time in supplying them with manure, and it is quite an open question whether—provided there is a sufficiency of labour to distribute the manure by manual labour—a greater acreage per day cannot be effected without the aid of a distributor. We have now to deal with a serious shortage of labour, and without saying that the implement as it stands to-day is not capable of material improvement, I say it behoves the agriculturist to see that suitable manure is put into the machine, as I do not believe that any machine will deal with unsuitable material. A really efficient distributor for farmyard manure is yet to be devised.

Artificial manure distributors either distribute the manure from a long box—corresponding very much to the box of a seed drill—from which it is distributed close to the ground by revolving stirrers which give a very uniform distribution; or else by means of centrifugal distribution in which the manure is placed in a hopper with an adjustable graduated opening at the bottom, by which the quantity per acre may be fixed, and it is then delivered on to a disc revolving as high speed with radial—or otherwise—projections thereon, which scatter the manure broadcast. To ensure an adequate trajectory these distributing discs must be a certain height above the ground, and if any wind happens to be blowing it must affect the distribution of the manure, and it is also inevitable that the larger particles carry further than the smaller ones. They are however, very compact simple machines, easy to manipulate, and if worked under suitable conditions give efficient results.

Reaping Machines.

Passing now to the second class of machines, those for gaining the crops, mowing and reaping machines occupy the first place, and I shall take the development of the reaping machine to apply to both.

The efforts made to supplant the scythe and sickle date from the time of the Gauls, but the progress made was insignificant. In 1780 this Society offered a gold medal for a reaping machine, and renewed the offer for more than twenty years without practical result. In the year 1806 a Mr. Gladstone invented a very remarkable machine embodying many of the leading features of the machine of to-day, such as: (1) the horse walks alongside the upstanding corn and well clear of it; (2) the action of the

machine tends to deliver the cut grain away from the standing corn, leaving a clear way for the horse on the next bout; (3) the mechanism is arranged between the two driving wheels.

Omitting intermediate machines, Common, a millwright in Northumberland, was the first to respond in a practical way to the offer made by the Society of Arts in 1812, in which he used open finger bars with reciprocating knives, a reel for holding the grain to the cutters, and a swathe delivery. Popular prejudice appears to have been against a reaping machine, and he did not proceed further.

The next important development I shall notice was made by the Rev. Patrick Bell, who placed his machine on the market in 1826. The cutting was done by open pivoted shears. The machine was pushed, and it had a revolving reel above the shears and an inclined apron behind them. This machine, with the addition of Hussey's open -guard cutting apparatus, was exhibited in the 1851 Exhibition, and it formed the rock foundation upon which further developments were built. From this time the progress of invention has been more rapid in America than here.

However interesting it might be to follow the further growth of the reaping machine in either country from the time when the division of the sheaf was done by a man walking by the side of the machine, then being carried thereon until the growth of the self-binder, time will not permit. I therefore pass to the trials of self-binder reapers in this country.

The first binder was exhibited by Messrs. Walter A. Wood in 1876 at Birmingham, but not being attached to a reaper it was impossible to try it. At Liverpool in 1877 a gold medal was offered for the best self-binding harvester, and three binders using wire and two using string competed. None worked sufficiently well to justify an award. Further awards were offered the following year at Bristol (1878), when three wire binders and one string binder competed. The award went to the wire binder, which did its work successfully.

Serious objection being taken to the employment of wire in binding straw which might be used as fodder, the Royal Agricultural Society offered a gold medal for a competition of binders in 1881 at Derby, using material other than wire. There were seven machines competing, and the gold medal was awarded to Messrs. McCormack. Further trials were conducted at Shrewsbury in 1884 with string binders, the awards going to Messrs. Hornsby and Messrs. Howard. The latest trials took place in 1893 at Chester, when the work done was almost as perfect as could be wished, the details of the Appleby knotter had been thoroughly mastered, and the percentage of imperfectly tied sheaves was quite insignificant. The separation of the sheaves was satisfactory. The uniformity of weight gave evidence of the efficiency of the packing, and the butting appliances satisfactorily regulated the position of the band.

During the time which has elapsed since the date of these trials, further improvements have been carried out, and though there was but small margin for improvement in actual work done, there has doubtless been considerable gain in the simplification and reduction of the number of parts, of improvement in the driving gear, in the introduction of roller and ball bearings, and last, but not least, of the height to which the grain has to be raised before binding. All these features tend to improve working of the machine and to a reduction in the draught. Attempts have been made to have a combined engine or motor and reaper; in 1876, at Birmingham, Messrs. Aveling exhibited a traction engine working a reaper with a 12 ft. cutting width, for which they were awarded a gold medal.

At the Paris Exhibition, 1900, Messrs. Deering and Messrs. McCormack both exhibited a reaper with combined motor, but nothing further seems to have come of the combined machine. At present preference is given to the hauling of one or more reapers by an independent tractor, as shown.

It has been suggested that a desirable development of the reaping machine should take the form of a combined reaper and thrasher, and attempts have been made in that direction. Necessarily this means a heavy cumbersome machine; there are, however, difficulties about its application to harvesting in this country: (1) Absolute uniformity in the ripeners of a crop in any field cannot be assured. As ripening continues after corn is cut, this matters little when the corn is allowed to remain in the sheaf. To thrash it immediately would bruise the unripened grain; (2) where clover or seeds are growing with the corn, it would inevitably choke the machine. The same would occur after a shower of rain, and operations would have to cease until the straw was dry enough to pass through the machine; (3) on ridge and furrow land, which is so common, the inclinations and levels of riddles, screens, etc., would be

continually varying, and efficient separation would be upset.

Haymaking.

The mowing machine being but a simplification of the reaping machine, I need here only state that for small-holdings a separate reaping attachment is made which converts the mowing machine into a reaper.

The early forms of haymakers consisted of a revolving skeleton cylinder with prongs mounted thereon, which by means of gearing revolved in the opposite direction to that of the travel of the machine, the hay was thus thrown over the machine, and though thoroughly loosened, was considerably knocked about. Subsequently the direction of rotation was reversed, making it the same as that of the machine, but running at considerably higher speed, the result being that instead of tossing the hay over the machine it was just lifted lightly off the ground and shaken out. This in a modified form is a useful machine where dealing with ridge and furrow. To reduce the bruising of the hay, several forms have been introduced, such as the hay tedder or kicker, which consisted of four or more spring forks mounted at the rear of the machine and actuated by levers and cranks which gave the forks a motion approximating to that of a hand fork, and gently turned the hay. The swathe turner was introduced with the same object in view. At first it consisted of two sets of screw blades, mounted on longitudinal shafts, at the rear of the machine, spaced to coincide with the spacing of the swathes. The blades had a serrated or saw edge, which in revolving just turned the swathe gently over. The latest arrangement consists of two or more spring tine rakes, the full width of the machine, placed at a slight angle to the machine and actuated in such a manner as to have a combined vertical and horizontal motion, independent of that resulting from the travel of the machine. The rakes may be so set that with one machine the several operations of tedding, swathe turning, and wind-rowing may be accomplished.

For collecting and loading hay several special rakes and loaders have been from time to time used in different parts of the country. At the present time any machine which will effectually take the place of hand labour is in demand, and we shall doubtless see loaders similar to the larger rick elevators in miniature placed behind the waggon in much more general use in the immediate future.

The most usual form of rick elevator is that commonly attached to the thrashing machine, consisting of an inclined Jacob's ladder, actuated either from one of the motions of the thrasher or else by independent horse-gear. Another form of elevator consists of a mast or pole with a lifting boom with pullies, through which a rope is reeved with a large fork suspended therefrom. A horse at the other end of the rope pulls up the fork with its load. Such an elevator was in constant work for several years about 1855: with it, however, the hay or corn as it was loaded into the cart was bound by two ropes, and was then lifted bodily out of the cart on to the rick. The work was done most expeditiously.

Thrashing Machines.

Without tracing the development of these from the thrashing floor of Araunah, or even much earlier, there are I presume some here who have seen the hand-flail in use as the means of thrashing, in which there was very little departure from the earliest methods. The first attempt at mechanical thrashing took the direction of working flails mechanically. Such was the nature of the machine invented by Mr. Menzies of Dalkeith in 1772, and of which it is stated that it "in a minute it gives 1,320 strokes, as many as thirty-three men thrashing briskly, and that it does not take more room than two men." It is not surprising that the machine knocked itself to pieces. The next development also emanated from Scotland, invented by Mr. Michael of Dunblane about 1750, on the principle of a flax-dressing mill worked by a waterwheel. We next find rollers applied for squeezing out the grain, as in the case in Rastrick's machine (erected 1778) in which rollers are combined with beaters.

The drum of to-day combines both the rubbing and beating actions, and has necessitated the expenditure of considerable thought and experiment to ensure efficient separation without injuring the grain or damaging its germinating properties. Such early machines as these were fixed in the barn building and were driven either by water-power, horse-power or a fixed steam engine, some of which were of a most primitive type. It was only about the middle of the last century that the movable thrashing machine and portable engine came into vogue.

Of the various farm implements perhaps none has gone through so many alterations and additions: the machines now have multiple blast, improved riddles and shakers, and leave but little to be desired in the samples of corn they turn out. Certainly they are the greatest

labour-saving machine on the farm. They are made from 3 ft. length of drum up to 6 ft. The larger machines go exclusively to the foreign markets. The most usual size for this country is the 4 ft. 6 in. machine, which deals with about seventy bushels of wheat per hour, and takes 16 b.h.p. to drive it. There is an increasing demand for the smaller machines consequent on the use of low-powered tractors, and also because the smaller farmers are now requiring machines.

Straw Elevator.

In conjunction with the thrashing machine a straw elevator is commonly used, where the straw has to be stacked. The first of these was exhibited in 1847, since which time many improvements have been made in arrangements for raising and lowering.

Straw Trusser.

In 1883 Messrs. Howard adapted the principle of the sheaf-binder to the packing and tying of the straw as it drops from the shakers. When the straw is to be immediately marketed this is a most important adjunct to the thrasher.

Straw Presses.

Owing to the bulky nature of straw or hay, presses of various designs have been devised for compressing it into bales. The Pilter Press was one of the earliest, consisting of a revolving cylinder into which the hay or straw is fed by means of two conical rollers, which twist it into a rough band, the amount of compression being regulated by the pressure on a plate closing the back of the machine. The density varies from 12 to 25 lb. per cubic foot. There is also the continuous press of Messrs. Howard, in which the hay or straw is delivered and packed into a long rectangular trough having a plunger with reciprocating motion, and when the desired compression is obtained the bale is wired and passed out of the machines. Hand baling presses are largely used for baling from the rick. Trials of these were conducted at Nottingham in 1888. For general purposes it does not seem necessary to resort to excessive pressures; so long as a ton measurement can be made to weigh a ton most requirements will be met and the straw will not be so severely broken up.

Chaff Cutters.

I now come to the several machines used in the farmstead for the preparation of fodder, etc. First of these is the hay or chaff cutter, the design of which has settled down to that of the revolving radial knife introduced by Comes in 1547, although there were earlier forms. The form and number of knives has been varied, but the convex form is now usually adopted. The features to which special attention has been devoted are the feed arrangements, safety appliances and guards in power-driven machines, in order to comply with the "Chaff Cutting" Machines (Accident) Act 1887.

Grist Mills.

It is difficult to put a date to the introduction of grist mills as such, as the regular preparation by grinding of food for cattle is of relatively modern growth, and the existing millstone was used for such purpose. They may, however, now be divided into: (1) Millstones; (2) flat metal discs serrated; (3) conoidal discs; (4) grooved rollers and breast; (5) rollers. These various machines were tested in competitive trials at Plymouth in 1890, and for general purposes the flat metal discs were proved to give the best results. There are also several forms of root slicers and pulpers. Such machines are ordinarily arranged in a food-preparing building and driven by an independent fixed engine. The power required being small it is not desirable to use an engine of such power as is necessary for ploughing or thrashing; it is found much better to have a small fixed engine of some 5 or 6 h.p. At present an oil engine is most suitable for the purpose, but where electric power is available nothing is more suitable than a small electric motor driving a line of shafting, the several machines being driven therefrom by fast and loose pulleys.

Prime Movers.

I shall now refer briefly to prime movers, which might well form the subject of a separate paper. Wind power was utilised at an early period, but owing to its uncertainty and irregularity it cannot be counted upon now for the carrying out of any work which should be done at a specified time and at a regular speed. Water power was used for driving many of the early fixed thrashing machines. There are many places where small water powers are available which have not been utilised. In any such cases advantage should be taken of them to drive an electric plant, from which not only may the lighting of the farm buildings be effected, but power for driving the farm machinery may be obtained. I can cite instances where disused water power flour-mills have advantageously been adapted to this

purpose. The portable steam engine has of late years been the most universally used. In its earliest form it consisted of a vertical steam boiler and independent vertical engine fixed on a platform mounted on low wheels. In 1842 there is the account of a high-speed disc engine which was successfully used to drive a thrashing machine. The same machine was exhibited a year later, the platforms carrying it having been enlarged sufficiently to take a thrashing machine, and the engine was self-propelling, so that the plant might move from farm to farm.

In 1849 the Royal Agricultural Society held its first trial of portable engines, built somewhat on present lines, *i.e.* with locomotive-type boiler and horizontal engine fixed thereon.

Time will not permit to go into the progressive improvements made. The diagram on the screen, plotted from the results obtained at various trials, however, gives a record of the advances made: (*a*) In 1849, when the engine was in its infancy, prizes were awarded to Messrs. Garrett and to Messrs. Clayton and Shuttleworth for their engines, the coal consumption then being 11·5 lb. per b.h.p.; (*b*) the next trials were held in 1850, when with a steam pressure of 45 lb. the consumption was reduced to 7·5 lb. per b.h.p.; (*c*) further trials were held in 1872 at Cardiff, the engines working at 80 lb. per sq. inch, the consumption was 2·75 lb. per b.h.p. These trials were most remarkable, as in the first trial two engines ran practically a dead heat and a second trial was made; (*d*) in subsequent trials at Newcastle in 1887, when the consumption was still further reduced to 1·85 lb. per b.h.p.

Looking at these results it may be pointed out that the great gain in efficiency between the first and second series of trials was due to improvements in design and increased steam pressure; and that between the second and third the gain was due to similar causes, but as might be expected at a very greatly reduced rate. When, however, we come to the Newcastle trials, following the dotted line of the diagram, which gives the results for the single engine—we find but very slight improvement, showing that for this type of engine as it stands finality is approached. And, following the red full line of the diagram, a largely increased improvement is due to the introduction during the interval between the trials of the high and low press cylinders or compound engine with its expansion valves. These last results were eminently satisfactory, as, considering the power of the engine, they compare favourably with the best results obtained by large power pumping and marine engines of the same date, which had the advantage of working as condensing engines. The temperature of the waste gases in the smoke box was reduced to a minimum. It remains to be seen what further economy may be effected by the use of superheated steam, which is now being applied in some engines.

Traction Engine.

The traction engine on the farm one is inclined to associate with the early endeavours made in road locomotion, though I have come to the conclusion that this is incorrect. During the period from 1825 to 1835 steam carriages were successfully carrying passengers from Paddington to the Bank, charging sixpenny fares, as well as in other parts of the country. That such was being done with a certain amount of success is beyond question, as a committee appointed by the House of Commons in 1831, and reporting in 1832, stated in brief: That carriages can be propelled by steam on common roads at an average rate of ten miles per hour, conveying upwards of fourteen passengers That they are perfectly safe for passengers. That they need not be nuisances to the public. That they are speedier and cheaper than horse-drawn carriages. That they admit of greater breadth of tyre than other carriages, and roads are not acted on so injuriously. That rates of toll have been imposed on steam carriages, which would prohibit their being used on several lines of road were such charges permitted to remain unaltered.

The last opinion expressed by the committee would appear to have been only too literally fulfilled, and the industry appears to have completely disappeared, and, indeed, history repeating itself, we all know how in later years the motor-car industry—to which we owe so much for the development of automatic machines, jigs and the like in engineering works—was for years driven out of this country to the Continent.

The agricultural traction engine has developed from the portable engine. I find as recently as 1859 a patent taken out by Mr. Aveling, of Aveling and Porter, which I think pretty conclusive on this point. I show it as a lantern-slide, from which it will be seen that a small sprocket wheel has been fixed on the crankshaft of a portable engine, which drives by means of a chain on to a larger sprocket wheel attached to one of the main road wheels of the engine. Later the shafts of the engine were substituted by a triangular iron frame with a fifth wheel pivoted at its apex, the steering being done through a tiller arm by a steersman seated in front of the

smoke-box. The chain drive in this engine continued in use until about 1872, when steel-cut gearing was substituted. Subsequent developments consisted in worm wheel and chain steerage from the platform of the engine, compound cylinders in 1880, spring mounting of the wheels, etc., in 1894. The design and workmanship of these engines by the leading makers leaves little to be desired.

Of late years there has been the introduction of the motor tractor and waggon. The former I have already referred to, the latter is a most convenient vehicle, as it dispenses with all the waste time in getting up steam on intermittent work, and is very easily handled.

It is to be hoped that with the experiences gained both at the seat of war, and with the effort being made by Government towards increasing the tillage area of this country, the advantages of motor transport will be realised, and that there may be some amelioration in the restrictions now controlling their use.

Water-supply.

There just remains one subject, and that an important one, to which I should refer—namely, the means of supplying water to the farm. Here the conditions vary very considerably.

If a moderate fall is available from a spring yielding good water, no more efficient method can be adopted—for a moderate supply—than that of a hydraulic ram, with a good storage tank at sufficient elevation to command all buildings. On the other hand, if the water has to be pumped it may be done, if the locality is favourable, with a wind engine, provided that sufficient storage is provided to carry through the longest period when there is little or no wind. In some cases the cost of this is excessive. An oil engine and pump is at present found generally the most convenient.

If water power is available, a small water-wheel or turbine with its pump may be used, but if such power is sufficient it is better, as I have already suggested, to utilise it in generating electricity and work the pump by means of a small motor. Electricity lends itself so easily to facile distribution that where possible it should be used.

I do not touch upon dairy machinery; this may well be dealt with separately. The success of the different appliances is so closely associated with the processes with which they are connected that they may be better dealt with in connection with them, rather than merely technically.

I have incidentally referred to the application of electricity for working farm machinery, but I believe there will be a very great move in this direction before long. Only a short time ago a very interesting paper was read here by Mr. Newlands on his work in connection with the investigation of water powers in Great Britain by a commission appointed for that purpose, and of which he is a member. True, the powers available as compared with those of other countries are but small, but for the most part they are in rural districts, and the very first persons who ought to avail themselves of such power are the agriculturists in their neighbourhood who may be in need of power. Much more important than this, however, is the work being done by another commission dealing with the conservation of our coal consumption; and there is every reason to hope that in the near future we shall have large generating stations close to the collieries, which will distribute high-tension current over extensive areas—as is done at Niagara and other places —which will open up a vista, the full extent of which at present it may be difficult to realise. But, given such distribution of power, at a price which will compete favourably with existing power, I have no doubt but that it will be readily adopted, as its convenience and adaptability will commend it for the several purposes required by the agriculturist. It has already been used in more than an experimental manner for ploughing, etc.

It may be asked even of such implements as I have referred to in this paper, how the smaller farmer, who is not a capitalist, is to equip himself with the needful machines.

I am quite sure with the inevitable shortage of labour, if the agriculturist is to keep pace with his foreign competitors, there will be the necessity for a considerable increase in the use of machinery, and I believe at the present moment he cannot do better than consider and evolve a system of co-operation in his district or county, and not only that, but each area—of heavy or light land—should decide precisely what type of machine is best suited to its requirements: in this I know he will receive the cordial co-operation of manufacturers, as it will tend to diminish the number of special machines, many of them of little use, which have been designed by or for "faddists," and it will further tend to simplify and standardise those of proved merit.

Where in the course of this paper I have referred to the names of certain makers, I have

done so merely because their name has been associated with a certain machine at a certain date. Where so many truly excel, it would be invidious to make any attempt at differentiating among them.

[The discussion on this paper will be published in the next number of the *Journal.*]

THE BUTTON INDUSTRY OF TONKIN.

The button factory at Hanoi is owned and operated by La Compagnie Industrielle du Tonkin, a joint-stock company with a capital of 350,000 francs (£14,000). The buttons are made of mother-of-pearl, obtained from the shell of a small mollusc (*Unio affinis*, Lea) found in abundance in nearly all the rivers of Tonkin and northern Annam, especially the Song-Ma near Thanh-hoa (Annam) and the Song-Cau near Bacninh (Tonkin). For years this mother-of-pearl has been used by the native artisans of Bacninh for inlay in furniture and other wooden articles, but the Hanoi button factory represents the first attempt by Europeans to exploit this resource.

According to a report by the United States Consul at Saigon, the factory consumes about 400 tons of shell a year. Last year it produced about 14,000 gross of buttons per month, but the monthly production will probably be raised to 20,000 gross within a year or two. Nearly every variety of mother-of-pearl button is manufactured, and the combination of beauty, cheapness, and a fair degree of durability makes competition in the local market extremely difficult. The trade-mark "Affina" is now known in France and England as well as in China and other countries of the Far East.

The factory consists of seven shops, in which the shells, after being steeped in vats for several weeks, are cut, ground, washed, punched, sorted, fastened, and polished. The machinery is entirely of French manufacture (Meru, Oise), or made on the ground after French models. Power is furnished by two 25 h.p. dynamos. The principal auxiliary materials used are stearine, lime, emery, paper boxes, and wrapping paper. The stearine comes from France (or America since the war), the lime is produced locally, the emery comes from France, or a substitute is produced locally, and the boxes and wrapping paper are manufactured in Tonkin.

The operating force consists of a European superintendent and about 350 natives, chiefly women. This number was expected to be increased to 500 by the end of last year. The work is done entirely by the piece. By working 10½ hours a day the men earn 7½*d.* to 10*d.*, and the women 4*d.* to 7½*d.*

Most of the product is consumed in the local market. Flat, round mother-of-pearl buttons are very well adapted to the white linen clothing of the tropics. The extent of the local market, the cheapness of raw material and of labour, and the adaptability of the product to local conditions, promise a good future for this industry.

OBITUARY.

SIR SAMUEL BAGSTER BOULTON, Bt., D.L.—Sir Samuel Bagster Boulton died at his residence, Copped Hall, Totteridge, on April 27th, at the age of eighty-seven.

He was chairman of Messrs. Burt, Boulton and Haywood, Ltd., timber merchants and contractors, of London, Paris, Riga, Salzaette, and Bilbao, and also of the Dominion Tar and Chemical Company, Ltd., and of the British Australian Timber Company, Ltd. He took an active part in promoting the application of scientific methods to chemical and other industries, and contributed to the literature of the subject. In 1884 he was awarded the Telford Medal of the Institution of Civil Engineers.

From 1889–1913 he was chairman of the London Labour Conciliation and Arbitration Board, and presided over the settlement of more than fifty labour disputes. He was created a baronet in 1905.

He had been a member of the Royal Society of Arts since 1882.

NOTICES.

NEXT WEEK.

MONDAY, MAY 13th, and TUESDAY, MAY 14th, at 4.30 p.m. (Cobb Lecture.) HENRY R. PROCTER, D.Sc., F.I.C., Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University, and Director of the Procter International Research Laboratory, "Recent Developments in Leather Chemistry." (Lectures I. and II.)

WEDNESDAY, MAY 15th, at 4.30 p.m. (Ordinary Meeting.) PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

THURSDAY, MAY 16th, at 4.30 p.m. (Special Lecture.) JOHN LEYLAND, "The German Freedom of the Sea." ADMIRAL SIR EDMOND JOHN WARRE SLADE, K.C.I.E., K.C.V.O., R.N., will preside.

Further particulars of the Society's meetings will be found on page 416.

TWENTIETH ORDINARY MEETING.

Wednesday afternoon, May 8th: SIR EDWARD ROSLING, Chairman of the Rubber-Growers' Association, in the chair. A paper on "The Rubber Planting Industry" was read by J. BRETLAND FARMER, D.Sc., M.A., F.R.S., Professor of Botany, Imperial College of Science and Technology.

The paper and discussion will be published in a subsequent number of the *Journal*.

SPECIAL LECTURE ON "THE FREEDOM OF THE SEA IN WAR."

Thursday afternoon, May 9th; LORD SANDERSON, G.C.B., K.C.M.G., in the chair. A special lecture on "The Freedom of the Sea in War" was delivered by SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., Chief Justice of Hong-Kong, 1905-12.

The lecture will be published in a subsequent number of the *Journal*.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

MAY 15.—PERCY GROOM, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology, "The Timber Industry."

MAY 29.—MARTIN O. FORSTER, D.Sc., Ph.D., F.R.S., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

INDIAN SECTION.

HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "The Cotton-mill Industry of India."

[The date will be announced later.]

SPECIAL LECTURES.

The last of the special course of three lectures on "The Freedom of the Sea" will be delivered on Thursday, May 16th, at 4.30 p.m.

LECTURE III.—By JOHN LEYLAND. Chairman, Admiral SIR EDMOND JOHN WARRE SLADE, K.C.I.E., K.C.V.O., R.N.

Syllabus.

THE GERMAN "FREEDOM OF THE SEAS."

Britain the great upholder of the Freedom of the Seas—The meaning of the term—How it was regarded by Grotius—How we came to be denounced as the "tyrants of the sea"—The attitude and policy of Napoleon—His claim to be the liberator from tyranny—The modern German claim a protest against British sea-power—An analysis of the claim—Its real meaning—The view held and expressed in the United States—The agreements and understandings with Prussia—President Wilson's declaration—How it is in conflict with the German claim—The need of a right understanding of the subject.

COBB LECTURES.

"Recent Developments in Leather Chemistry," by HENRY R. PROCTER, D.Sc., F.I.C., Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University, Director of the Procter International Research Laboratory. Two Lectures.

Syllabus.

LECTURE I.—MAY 13.—Structure and chemistry of skin—Processes for removal of hair and epidermis—Removal of lime and preparation for tanning—Use of bacteria and enzymes—Dehydration and separation of fibrils—The pickling process—Nature of colloid swelling.

LECTURE II.—MAY 14.—The conversion of the pelt into leather, and the nature of the change—Tannage with mineral salts—Alumina tannage—Chrome tannage—Vegetable and synthetic tannins—Tannages with aldehydes, quinones and bromine, and with colloidal precipitates—Oil tannage—Summary.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 13...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cobb Lecture.) Dr. H. R. Procter, "Recent Developments in Leather Chemistry." (Lecture I.)

Chemists, British Association of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m.

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Dr. S. Chapman, "Terrestrial Magnetism."

Geographical Society, Burlington-gardens, W., 8.30 p.m. Mr. J. M. MacLeod, "The Achievements of France in Morocco."

TUESDAY, MAY 14...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Cobb Lecture.) Dr. H. R. Procter, "Recent Developments in Leather Chemistry." (Lecture II.)

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 6.30 p.m. Discussion on "The Lighting, Heating, and Power Order (1918), and the best methods of making Economies."

Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Dr. J. C. Stamp, "The Effect of Trade Fluctuations upon Profits."

Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Keith, "Field Anthropologists." (Lecture IV.)

WEDNESDAY, MAY 15...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. P. Groom, "The Timber Industry."

Geological Society, Burlington House, W., 5.30 p.m.

Colonial Institute, Caxton Hall, Westminster, S.W., 8.30 p.m. Paper by Professor McLaughlan (U.S.A.).

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor W. M. Bayliss, "Accessory Components of Food."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5.15 p.m. Lecture by Professor W. L. Courtney.

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Mr. C. E. P. Brooks, "Continentality and Temperature—The Effect of Latitude on the Influence of Continentality on Temperature." (Second Paper.) 2. Messrs. J. E. Clark and H. B. Adames, "Report on the Phenological Observations for 1917."

THURSDAY, MAY 16...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Special Lecture.) Mr. J. Leyland, "The Freedom of the Sea. Lecture III.—The German 'Freedom of the Seas.'"

Royal Institution, Albemarle-street, W., 3 p.m. Professor Sir J. G. Frazer, "The Prosecution and Punishment of Animals." (Lecture II.)

FRIDAY, MAY 17...Royal Institution, Albemarle-street, W., 5.30 p.m. Dr. A. B. Rendle, "The Story of a Grass."

SATURDAY, MAY 18...Royal Institution, Albemarle-street, W., 3 p.m. Dr. W. L. Courtney, "Dramatic Realism." (Lecture II.)

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NOTICES.

COBB LECTURES.

On Monday and Tuesday afternoons, May 13th and 14th, PROFESSOR HENRY E. PROCTER, D.Sc., Director of the Procter International Research Laboratory, delivered two lectures on "Recent Developments in Leather Chemistry."

On the motion of the CHAIRMAN, a vote of thanks was accorded to Professor Procter for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

TWENTY-FIRST ORDINARY MEETING.

Wednesday afternoon, May 15th; PROFESSOR WILLIAM BATESON, D.Sc., F.R.S., Director of the John Innes Horticultural Institution, in the chair. A paper on "The Timber Industry" was read by MR. PERCY GROOM, M.A., D.Sc., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology.

The paper and discussion will be published in a subsequent number of the *Journal.*

SPECIAL LECTURE ON "THE FREEDOM OF THE SEA."

Thursday afternoon, May 16th; ADMIRAL SIR EDMOND JOHN WARRE SLADE, K.C.I.E., K.C.V.O., R.N., in the chair. A special lecture on "The German 'Freedom of the Seas'" was delivered by MR. JOHN LEYLAND.

The lecture will be published in a subsequent number of the *Journal.*

Journal of the Royal Society of Arts.

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FRIDAY, MAY 17, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, April 18th, 1918; LORD LAMINGTON, G.C.M.G., G.C.I.E., in the chair.

The paper read was—

WATER POWER IN INDIA.

By ALFRED DICKINSON, M.Inst.C.E., M.I.E.E., M.I.Mech.E.

I have been invited by your Committee to read a paper on "Water Power in India." As a preliminary, I desire to point out that, although I am responsible for installing the largest water-power scheme in India, my knowledge of the possible sources of water available for power in the whole of India is very limited. Therefore I shall not be able to do more than touch the fringe of the subject.

It is, perhaps, desirable to mention at the outset a few elemental, though important, points to be borne in mind before deciding to install water-power, whether in India or elsewhere. Not only industrial, but also agricultural development is now largely dependent upon cheap power. Cheap power is a relative term, and its consideration needs discrimination, for although the cost for power produced from coal at 5*s*. per ton should only be for that commodity one-fifth of the cost if produced from coal at 25*s*. per ton, the relative cost of production may be cheaper by the dear coal. As coal is the chief item of cost for steam-power, so water is the principal item of cost for water-power.

In cost for water-power, interest on the capital expenditure incurred in hydraulic development and the maintenance of the same must be included. Commercially, the permissible capital expenditure on hydraulic development is largely controlled by the cost of coal, or other competing power-producing commodities.

With coal at 5*s*. per ton an expenditure on hydraulic development of, say, one-fifth is permissible as against such an expenditure in a locality where coal costs 25*s*. per ton. Wherever the cost per horse-power is less for coal, or other similar power-producing commodity, than the payment of interest on capital expenditure for hydraulic development and maintenance, water-power becomes a doubtful commercial proposition. A larger expenditure per horse-power on hydraulic developments is permissible where the water is impounded for power and irrigation.

In most manufactured products the cost of power is an important item, but it is of far greater moment to some industries than others, for what would be cheap power to a producer of textiles would be dear and prohibitive power to a manufacturer of aluminium, nitrates, cyanamide, and such-like commodities.

The recent rapid development of electro-chemical knowledge demonstrates that a more world-wide demand exists to-day for cheap power than a short time ago would have been thought possible. The demand for power by electro-chemical industries will justify the development of many sources of water-power which may have been considered thus far of little or no value.

The food problem is a very serious one. This was foreseen by Sir William Crookes when he observed that "As mouths multiply, food resources decrease." This is particularly so as regards India. The land has been for many years cultivated without receiving—in so large a measure as in most countries—assistance from the natural animal fertilisers which have been largely used up, and still continue to be used, as fuel. Therefore, so far as India is concerned, if the mouths are to be fed, the time has arrived when agriculture must be aided. This, in a large measure, can be accomplished by supplying to the earth fertilisers manufactured by cheap water-power.

The abstraction and fixation of nitrogen from

the air is now no longer in an experimental stage. Given cheap electrical energy the manufacture of nitrates is a sound commercial proposition. Electro-chemical knowledge is still in its infancy, but it has progressed sufficiently far to demonstrate that fertilisers can now be manufactured which are of far greater value to the land than the ordinary natural fertilisers, and at a cost to justify their general use.

Various combinations can be made to suit the requirements of any locality. The nature of the earth having been ascertained, the fertilisers necessary to give the best crops can be supplied at a cost which will more than justify the expenditure.

Sufficient has been indicated to show that cheap power is not only desirable for manufacturing industries, but that it is now a necessity for agricultural development. This has been mentioned to draw attention to the great value water-powers may be to agriculture in districts far remote from the manufacturing centres. Many water-powers remain dormant because the cost of transmission to districts where there is a demand for power is prohibitive.

Electro-chemical industries may be established in the vicinity of water-power, thus avoiding capital expenditure on long transmission lines.

Before considering possible water-powers it may, perhaps, be more interesting first to give a few particulars of one or two of the schemes already developed. The most important scheme thus far is that of the Tata Hydro-Electric Power Supply Company. It is frequently said that engineers lack imagination, and that there is no such thing as romance in engineering. I believe that the Tata Hydro-Electric scheme disproves these statements. The general impression is that water-power is the utilisation of the water of existing rivers or lakes. The Tata Hydro-Electric undertaking is not of that character; it is a scheme to provide, approximately, 100,000 water horse-power from valleys which have from time immemorial been dry for nine months of the year, and where no water had been previously stored. The valleys were so dry that one of the initial difficulties in converting them into lakes was to provide water for use in building the masonry dams.

When the scheme was in process of development I was advised by engineering friends not to risk my reputation by being associated with "such a perfectly absurd engineering proposition," and on generally accepted engineering principles I admit that if the scheme had been placed before me for advice I should have reported against it. Many looked upon the question, not as a serious engineering proposition, but as a fairy tale. But even in engineering the exception proves the rule. The Tata Hydro-Electric scheme can only be justified on that ground. This will be appreciated when it is stated that, even after the work of building the dams had been in hand for some very considerable time, the Company were advised that the supply of water would be insufficient because the catchment area could not yield water to fill the lakes.

Those versed in these matters will agree that the engineer did not lack confidence who advised that rain falling during the monsoon on a total catchment area of 22 square miles would be sufficient to enable, roughly, 100,000 water horse-power to be developed for 3,600 hours in each year, but it was confidence begot by experience and knowledge, and now justified by results. The catchment area is exceptional to the extent that almost all the water falling runs off.

Mr. R. B. Joyner, C.I.E., who had special knowledge and long experience of this district, made the detailed investigation of this part of the scheme, and it was upon the results of his investigation that I relied.

His report showed that on the eastern side of the crest of the Western Ghats, the rainfall was not only enormous in quantity, but in intensity also.

Rainfall.

It was demonstrated that it was rare for the annual rainfall to be less than 12 ft., that generally it was from 18 to 20 ft., and that occasionally it was 26 ft., this enormous quantity falling within four months. Twelve inches is not unusual, and as much as 20 in. have been known to fall in twenty-four hours. The average fall per day in forty-five days for thirty-four years was about $3\frac{1}{4}$ in.

It has since been demonstrated that approximately 90 per cent. of the rain falling on the catchment area is caught and stored. The investigations covered a period of thirty-four years, and during that period the maximum rainfall was 320 in., the minimum 90 in., and the mean approximately 200 in.

The care necessary, and the experience needed, to arrive at reliable results, is demonstrated when it is pointed out that rain-gauges placed less than half a mile distant from each other showed that the quantity of rain falling on the areas checked varied enormously. The readings

of the rain-gauges during one monsoon of ninety days showed that, whilst rain falling in the valleys approximated to 250 in., during the same period a gauge on the top of one of the hills registered no less than 540 in. So far as I am aware this is the highest recorded rainfall *in the period* throughout the world.

Lakes and Dams.

Three large lakes have been formed by constructing dams across three valleys, known as Lonavla, Walwhan and Shirawta, the hearting of the dam being of uncoursed rubble masonry, and the facings of coursed rubble masonry.

The Lonavla Dam is 3,600 ft. long, and 40 ft. high from the bottom of the foundations. The Walwhan Dam is 4,500 ft. long, and 75 ft. high from the bottom of the foundations. The Shirawta Dam is 8,000 ft. long, and 100 ft. high from the bottom of the foundations. The Shirawta Lake is connected to Walwhan Lake by a tunnel 5,000 ft. long through the hills. The water to the tunnel is regulated by sluices fixed in a headwall at the Shirawta end of the tunnel.

From these lakes water is conveyed in an open duct, roughly four and a half miles long, having a capacity of 120,000 h.p., to the forebay. The forebay has a storage capacity of about one and a half hours for the whole of the eight sets working. Openings are provided in the dam of the forebay for three 82-in. pipes.

Pipeline.

From the forebay is a steel pipeline, which carries water down the steep slopes and cliffs to the power-house at Khopoli in the plains below. The pipeline has been designed in two sections, namely, for two upper and eight lower pipes. At present there are installed one upper and five lower pipes. The pipes are laid above ground, proper provision being made for variations of temperature by expansion joints inserted between fixed points in the upper pipeline, and at each thrust block in the lower pipeline.

Power-house.

The full scheme is for a plant capacity of, roughly, 96,000 h.p., divided into eight main sets of 12,000 h.p. each. In addition, there are two 850 h.p. exciter sets, eight step-up three-phase 10,000 k.v.a. transformers, each bank consisting of three single-phase transformers, with the necessary switchgear, station auxiliary apparatus, and four outgoing transmission lines. The main generating sets are impulse turbines of the horizontal type, running at 300 revolutions per minute, direct-coupled to the three-phase enclosed self-ventilating generators.

Some idea of the size of the transformers will be gathered when it is stated that, filled with oil, each weighs 24 tons. It takes eight tons of oil to fill each transformer.

The switchgear system is arranged for operating each unit with its own transformer bank. The high-tension oil switches are for automatically tripping by inverse time limit overload series relays. All auxiliaries are operated by three-phase current, 440 volts, and all the high-tension switches are operated by remote control.

Transmission Line.

The route of the transmission line is from the power-house at Khopoli to the receiving station on the Island of Bombay, a distance of forty-three miles. The line crosses two tidal creeks (one of which is 10,000 ft. wide, and 42 ft. deep at high tide), a railway, and several roadways.

Two change-over stations are provided, each with air-break disconnecting switches, which divide the line into three sections for cutting out or interconnecting different sections as required.

Stranded copper conductors are used, and are placed 10 ft. 6 in. apart.

Receiving Station.

The receiving station is situated at Parel on the Island of Bombay, and has a plant capacity to deal with the output of the power-house. The switchgear system consists of remote control electrically operated oil switches and other apparatus.

The feeder system from the receiving station to the mills is designed for a 6,000 volts, 50 period, three-phase supply, with an unearthed neutral. The cables are of the three core paper, insulated lead covered type, and are laid on the solid system in between in earthenware troughing about 18 in. below the footway.

For the purposes of the feeder system, the cotton-mills are arranged in groups, there being a feeder to each mill with an emergency ring feeder connecting up all the mills of the group.

Mill Equipments.

The problem presented by the cotton-mills of Bombay was the conversion from mechanical to electrical drive, utilising the existing shafting,

and the change to be effected with as little interference as possible with the production of the mills. The problem was thoroughly investigated and, after consideration, group-driving with direct-coupled motors was adopted as being best suited to the requirements of the Bombay industry. Standard speeds of 265, 290, and 365 revolutions per minute were adopted.

The motors are of the slip-ring induction type, wound for 2,000 volts, provided with the slip-ring and brush-lifting and short-circuiting gear enclosed, and are standardised to about six mechanical sixes for renewals and spare parts, and in windings ranging from 30 to 500 h.p. They are designed for driving from either end of the shaft. The full load efficiencies range from 87 to 92·5 per cent., and the full load factors from ·74 to ·84. The starting switches are of the liquid type, the electrodes being operated through slow-motion gear. In the case of callender machines, special starters are supplied to meet the conditions of service.

The mill transformers are of the three-phase, 6,600–2,200 volts, 50 period, oil insulated, air-cooled core type, star connected on both sides, and are provided with an earthing device. They are supplied in four sizes, 500, 600, 700 and 900 k.v.a., from which the power requirements of each mill are met. They have at full load, and a power factor of ·80, an efficiency of about 98 per cent., and a regulation of 2·4 to 2·7 per cent.

As a result of the adoption of electric drive, I have been informed that a much better yarn is produced, and, in addition, with the same textile machinery the output has been considerably increased.

The satisfactory supply has increased the demand for power beyond the capacity of the present plant installed, with the result that in order to meet it other works and plant are now under construction, known as the Andhra Valley Electric Supply. It is anticipated that, when completed, this plant will enable the company to meet all the demands likely to be made by Bombay in the near future. Contracts have already been entered into for approximately 100,000 h.p. The price per unit is ·5 of a penny, and when it is borne in mind that coal in Bombay is, roughly, three times more costly than in England, it will be seen that this is a very low charge.

Important as are the advantages derived by the textile industry of Bombay, they are small when compared with the enormous benefits the population of that city derive by the abatement of the smoke nuisance. Already smoke from some forty chimney-stacks has gone, and it is hoped that shortly it will disappear from all of them. Those who know Bombay will appreciate how much more agreeable life will be in that city when the dense palls of smoke which overhang it vanish.

So far as I have been able to ascertain, the first hydro-electric system in India was the small plant of the Darjeeling Municipality, installed in 1896. Prior to the installation of the Tata hydro-electric system, the most important scheme was that of the Mysore Government at the Cauvery Falls. This scheme was decided upon about 1897, and energy first supplied in 1902. The original scheme contemplated the installation plant of 6,000 e.h.p., the electrical energy generated being transmitted to the Kolar Goldfields to replace in part the steam-power used by the mines, the transmission voltage being 30,000 volts. Extensions have been made, so that at the present time the power-house has a capacity of 22,650 e.h.p. Power is transmitted to the mines at 78,000 volts, and to the cities of Bangalore and Mysore at 35,000 and 22,500 volts respectively. Electrical energy is generated at 2,000 volts. The transmission line to the mines is ninety-two miles in length, this being in duplicate. Bangalore is fifty-seven miles and Mysore thirty-seven miles from the power-house.

By drawing the water from the river about two miles above the falls, and conducting it through an open channel about 17,000 ft. in length to the power-house, about one mile below the falls, a head of 405 ft. is obtained. During the months of February, March, April and May, the normal discharge in the river falls below requirements. Consequently a reservoir of approximately 37,000 m.c.ft. storage capacity is being constructed at Kushmaraja Sagara. This reservoir is on the Cauvery River near to Mysore. Provision has been made for four penstocks in the reservoir dam. When the dam is completed to its final height, 4,000 e.h.p. can be generated and fed into the present system at Mysore city.

The State of Patiala possesses a small installation for city lighting.

There is a hydro-electric station of moderate size on the Bhatti Nadi. The power here generated is transmitted to Mussoorie and Dehra. The power-house is situate 7½ miles from Mussoorie and contains generating plant of 1776 k.v.a. capacity. The minimum dis-

charge of the stream is about 9 cubic ft. per second. The pipeline consists of two lines of mild-steel pipes. It has a total length of 4,350 ft., and a varying diameter of 16 in., 14 in. and 12 in. The total fall in the pipeline is 992 ft. High-tension lines are run to Mussoorie and to Dehra, 6,600 volts pressure. There are fourteen substations in Mussoorie, and five in Dehra. Distribution is carried out on a low-tension system for lighting purposes in the two towns named, and for pumping water for the supply of Mussoorie.

Simla is now supplied with electrical energy generated by water-power.

In the Native State of Kashmir and Jammu, water-power plants have been installed on the river Jhelum and at Jammu. In the case of the Jhelum installation, water is obtained from the Jhelum River, the power-house being at Mohora. The hydraulic works and pipeline arrangements carried out up to the present have a total capacity of 20,000 h.p. Water is conveyed a distance of six and a half miles from the river to the forebay by means of a timber flume 8 ft. 4 in. wide by a depth of 8 ft. to full supply level.

The forebay is arranged for eight intakes, of which four have been provided with steel pipelines. Each pipeline is 600 ft. in length, and there is a total vertical head of 405 ft. from the forebay to the turbine, with an effective head of 395 ft. The arrangement of valves on the pipelines is such that any one unit can be served from either of the pipelines.

The power-house plant consists of four vertical turbines, each direct-coupled to a 1,000 k.w. three-phase 2,300 volts, 25 period, generator running at 500 revolutions per minute, each unit being capable of sustaining an overload of 25 per cent. for two hours, and two exciters each of 150 k.w. capacity, and capable of exciting 5,000 k.w. of generator capacity. There are two banks of transformers, each of 3,100 k.w. capacity at 2,300 volts primary, and 60,000 or 30,000 volts secondary, with an additional tapping for 50,000 volts. The transformers are oil-immersed and water-cooled, and are delta-connected in each bank. The transformers are operated through remotely controlled oil switches.

There are two outgoing transmission lines from the power-house. These are run side by side as far as Baramula, twenty-one miles distant, at which point one terminates, while the other is continued to Srinagar, a further thirty-four miles. Each transmission line consists of three conductors of six strand No. 10 Brown and Sharp gauge copper mounted on 60,000 volt insulators, pin type, and is carried upon timber structures.

A metallic circuit telephone line is run upon the same poles as the transmission line, and is connected to telephone instruments at about every ten miles of the line. Induction troubles were experienced with this line, but these have been overcome by transposition of the E.H.T. conductors. Galvanised iron wires earthed at every pole are run the whole length of the lines, and fastened to the top cross arms as lightning conductors.

At Baramula and in its vicinity there were originally three floating substations, each containing one bank of three 200 k.w. step-down transformers—1,800 k.w. in all—this supply being used for the working of dredgers and dredger derricks, and the supply of light to the town of Baramula. The E.H.T. line to Srinagar has been tapped near Sopore, at a distance of about seven miles from Baramula, and light supplied to that town.

The line has also been tapped at a point halfway between Baramula and Srinagar, and a three-phase line is run for a distance of fourteen miles to Gulmarg. The supplies given at the three before-mentioned places are small.

At Srinagar the transmission line terminates in a silk factory substation, in which there are installed five 500 k.w. 60,000–30,000 to 2,300 volts transformers. The silk factory calls for a load of 1,700 k.w. From this substation a 2,300 volts transmission line has been run to Basant Bagh, where public lighting is carried out, the maximum load being 450 k.w.

The hydro-electric installation for the generation of electrical energy for supply to the city of Jammu is situate on the Irrigation Canal. There is but a low head of 26 ft., and the plant installed is 772 k.w. There is an overhead transmission line at 3,000 volts. The output of power is principally utilised in connection with the Maharaja's palace, the waterworks, and the lighting of the city.

Hydro-electric power has even penetrated into far-off Afghanistan, where the Amir has had installed a small plant for supplying light and power to Kabul.

The Governments of Canada, New Zealand, Tasmania, and the United States realise how important water-power is to their respective countries, and have had elaborate surveys made showing the location and particulars of the more important water-powers. This enables those interested to ascertain what powers are

available for development without incurring the heavy expense of preliminary surveys and local investigation. The question of water-power to these countries is relatively unimportant compared with India; in India, not only is cheap power important, but water for irrigation is in many cases vital.

My view is that the Indian Government should at once undertake a complete investigation of the possible sources of water-power in the country, and that the information thus obtained should be available for public use. Perhaps this will follow as a corollary to the investigations of the Industrial Commission.

Private enterprise has already done much, and is doing more. Messrs. Tata, Sons and Co., Bombay, have been the pioneers, and continue to lead the van. As a result of investigations made at their expense, it can now be demonstrated that, by constructing a dam across a valley in the Western Ghats, water from the Koyna River can be harnessed so as to provide approximately 300,000 h.p. continuously. The preliminary estimates of cost show this scheme to be a thoroughly sound commercial proposition.

In my opinion this is a discovery of the highest importance to the whole of the East. If a Niagara had been announced the world would have been agog, perhaps more from a spectacular than a power-producing point of view. When the possibility of supplying 300,000 h.p. for every hour in the year is appreciated, it will be seen that it is equivalent to supplying to industries during the normal working hours of 3,600 per annum no less than 730,000 h.p. for each and every working hour of the year.

Consider the possibilities this creates. Seven hundred and thirty thousand horse-power for ten hours each day for 360 days in each year supplied at, say, one-third of a penny per horse-power hour. This should give to India the greatest industrial fillip she is ever likely to receive from any single discovery.

I am investigating the possibility of utilising for power purposes the irrigation lake at Periyar, in the Madras Presidency. So far the investigations show that a thoroughly workable and commercial scheme for the manufacture of nitrates on a large scale can be established. The dam, lake, tunnel, and other works in connection therewith were fully described by the late Colonel J. O. Hasted, R.E., in the paper read before this Society on April 30th, 1891.

I am aware that power can be obtained from the Bari Doab Canal and the Dudh Sagar Falls, and I have every reason for believing that very considerable power can be secured in many parts of India. My departure for India, together with the pressure of business, precludes the possibility of my going into details.

The advantage of water-power development in India will be apparent to those interested in, or who appreciate, the industrial awakening of that vast Empire, for water-power development can, and will, materially hasten that awakening.

The rapidity of industrial and agricultural development will, in my view, be largely dependent upon a closer union between the East and West.

India possesses in abundance the necessary minerals for metallurgical development; the climate and land needful for the cultivation of cotton, flax, jute, and many other commercial commodities; and an enormous and intelligent population which, if properly trained, will provide skilled workers in great numbers. In addition, its available capital is substantial.

Although much has been done, her industrial possibilities, to use a vulgarism, have scarcely been "scratched." It is well known that not infrequently the obvious is overlooked. My view is that so far as the captains of finance and industry in the West are concerned, they have not been altogether ignorant of the industrial possibilities in India, but hitherto have not shown the necessary confidence by taking part in our helping forward rapid development. They had an opportunity to finance and construct the Tata hydro-electric scheme, but failed to appreciate its importance. It was therefore left to India to find the requisite capital, to the great advantage of the Indian investor, for this is the only electrical undertaking of magnitude which, in the first year of its working, has earned and paid a dividend on its full capital; and, although it is as yet incomplete, it is earning a profit of over £190,000 per annum.

[Owing to the absence of Mr. Dickinson in India, the paper was read by Mr. E. S. Woollard Moore, Assoc.M.Inst.E.E.]

DISCUSSION.

The Chairman (Lord Lamington) said that not very long ago he had the honour of presiding over a meeting of the Society when a paper dealing with the great Tata iron and steel works in India was read, and he remembered what a wonderful undertaking was then revealed. On the present occasion everyone present must feel that he had

been listening to another fairy tale in revelation. There were one or two points that he would like Mr. Moore to explain more fully. For instance, referring to the main scheme, the Bombay scheme, it was said in the paper that the catchment area was exceptional to the extent that almost all the water falling ran off, and he did not quite understand the meaning of those words. Also, could Mr. Moore account for the fact that the yarn was much better when the motor power used was electricity. He would also like to know whether the pipe track of two and a half miles with a fall of over one thousand seven hundred feet, was not almost a world record. It was stated in the paper that the Tata Hydro-Electric undertaking provided 100,000 h.p., and in comparison with that it would be interesting to know what was the power derived from the Niagara scheme in Canada. It was very satisfactory to think that already the supply, great as it was, had been overtaken by the demand in Bombay City. He understood that the scheme was not yet in full operation, and he would like to know whether the proposal to use the Andhra water-supply was to be in connection with the Bombay scheme or quite a distinct undertaking. He was glad to learn that not only were the industrial benefits derived by Bombay from the Tata Hydro-Electric undertaking such a great blessing, but that Bombay had been relieved of the smoke that had disfigured what was in his opinion one of the most majestic and beautiful cities on the face of the globe. With regard to the remark in the paper that the rainfall varied considerably at places within half a mile of one another, he was reminded that at Mahableshwar the rainfall was over three hundred inches, whereas it was only sixty inches at Panchgani, eleven miles distant, showing the effect that difference of altitude had on precipitation. In the Koyna Valley there was a tremendous quantity of water flowing to waste, and there were many waterfalls in the Bombay Presidency, and perhaps still further south, which in time to come might be utilised for the development of power. He agreed with the author that it would be very advantageous if the Government of India had a complete survey made of all those possible sources of supply, which ought not, in his opinion, to be worked by the Government, but by private people. He did not quite agree with the remark of Sir William Crookes quoted in the paper that "As mouths multiply, food resources decrease." Two or three hundred years ago the population of this country was very much smaller than at present, but the food supply had increased out of all proportion to the increase in population. He thought the increase of population was rather dependent upon the increase of food supplies. In these days, when human enterprise and intellectual power had developed in such a marvellous fashion, of which an instance was given in the paper, it was a very sad reflection that at the present moment all the resources of human ingenuity were being devoted to the destruction of all that had been built up in the past.

Sir Charles H. Armstrong said the subject of the paper was a very interesting one to those who had lived in Bombay, as he had done for thirty years. He remembered the discussions that took place when the Tata Hydro-Electric scheme was under consideration. It was stated in the paper that it was then looked upon as a perfectly absurd engineering proposition, and he believed the reason was that it was thought the trap-rock would not hold the water. He was astonished, however, to learn that, after the work of building the dams had been in hand for a considerable time the Company were advised that the supply of water would be insufficient because the catchment area could not yield water to fill the lakes; and he thought everyone who knew the ghats round about Bombay and the enormous rainfall of that mountainous district would be surprised that that point had ever been raised. He was pleased to hear that the smoke nuisance in Bombay had been to a very great extent abated by the scheme of the Tata Company. Twelve or thirteen years ago, when the Port Trustees of Bombay were making their annual inspection, Lord Lamington was their guest, and seeing the smoke lying over Bombay, he expressed the wish that something could be done to remove it. It had now been removed to a great extent, and he was very glad to hear that so many mills had adopted the electric drive. He remembered, however, that just before the Tata Hydro-Electric scheme was started he happened to be a director of one of the largest and best-equipped cotton-mills in Bombay, and when the question was raised as to whether the steam drive or the electric drive would be the cheaper the engineers of those mills advised the directors to continue working by steam. There was no doubt that at the present time, certainly in Western India, electrical power was a very important matter, one of the reasons for that being that the cost of Indian coal was steadily increasing, and that in the future the coal was likely to be a great deal more expensive than it was before the war. Bengal coal before the war used to come to Bombay by sea, but now it had to come overland by rail, which was costly, and its transport had seriously interfered with commercial traffic and also, to a certain extent, with military traffic. He happened to be connected at the present time with the Great Indian Peninsula Railway, which, with the Bombay-Baroda Railway, served Bombay, and had a very large suburban traffic. It would be a very great advantage if that traffic could be worked by electricity. It would be an advantage also if the ghat traffic of the Great Indian Peninsula Railway could be worked in the same way. At the present time the Great Indian Peninsula Railway had a very large scheme under consideration; an engineer was investigating the matter in India, and no doubt, sooner or later, that railway would adopt electricity on a very large scale. In and near Bombay it would probably use water-power, the water being obtained from the ghats in the same way as the Tata schemes were now being worked, and the

Company might possibly work in conjunction with the Tata Company. The railway was also considering the possibility of using oil, which was certainly cheaper than coal, and it might be that in and near Bombay it would be found cheaper to use oil than electrical power. Electrical power, however, had a very great future before it in India, and if the money was forthcoming—as it certainly ought to be, because India was very prosperous—it would be possible in the near future to make very great headway in that direction.

Mr. C. H. B. Burlton said the paper was most opportune. The British Administration in India had been very conservative in some respects, which was the reason why many of the developments now taking place had not been carried out before. Probably the first of the hydro-electric schemes set on foot was that alluded to in the paper, the Cauvery Falls scheme. He remembered in the late nineties being shown over the works that were then being started in connection with that scheme by Colonel McNeill Campbell, the chief engineer of Mysore. The works were conducted under Colonel Campbell's auspices, and were under the direct execution of Colonel, then Captain, de Lotbinière, who had made his mark in the engineering world in India. It was very encouraging to note that there were many works of a similar nature now in existence, and that water-power had been used for the generation of electricity. There were, however, many cases where water was being allowed to go almost to waste. For instance, the Nilgiri Railway was constructed after engines were first run by electricity, and although that line had been in existence for about twenty years it was still run by steam, and the enormous amount of water-power in that district was therefore going to waste. The Kateri Falls, for example, were unharnessed and within easy distance of the Nilgiri Railway. It was a great pity that that railway was still worked by steam, because of the expense of bringing coal such a great distance, there being probably no coal worked much south of Bengal. About twelve years ago there were five high masonry dams in India, and he did not think any of them had yet been harnessed for the purpose of transmitting power over any distance to supply towns with electricity or for the benefit of works. Progress was now being made in connection with such matters, however, and the paper showed that India might soon pass from industrial infancy into industrial adolescence or even manhood. It was very important that the resources of the country should be utilised in the country itself. There was a very great need for fire-bricks in India at the present time, and they were now being imported in very large quantities, but he believed that if they were manufactured in the country, then, with hydro-electricity available, the prosperity of India might be ensured industrially as it had been already ensured agriculturally.

Mr. Alph. Steiger, M.Inst.C.E., said that one of the first water-power installations was that developed at the cotton-mills at Gokak, in the Bombay Presidency, in 1885. At that time practically nothing was known about electrical transmission, and there the power—amounting in all to 750 h.p.—was transmitted by wire ropes from the bottom of the cliff to the top and along a few hundred yards to the mills. Seven years after that the electrical transmission plant at Frankfort was developed, and proved to be a success, and when the mills at Gokak required more power the question arose whether electricity could not be applied there, but the idea was abandoned, as at that time not sufficient experience was available as regards the influence of the climate, monsoon, and thunderstorms on electrical transmission. The plant was extended to 2,000 h.p., again using the wire-rope transmission; but a few years ago the whole of the transmission plant was scrapped and the electrical system adopted, which had proved a great success, the whole of the machinery in the mills being driven by electricity. The next hydro-electric installation was the Cauvery power-plant, which he had the honour to design, and that plant showed the progress that had been made within the last decade or so. The fall there was about 300 ft., but the units were not larger than 1,250 h.p. each, whereas if the same plant were to be installed now units would probably be adopted of 3,000, or perhaps 5,000 h.p. He ought to mention, however, that at that time the total power from the Cauvery River was not so great that it would have justified so large a unit; but still, instead of six units of 1,250 h.p., two or three units of 3,000 or 4,000 h.p. might have been put in at considerably less cost. The second extension of that plant, made a few years afterwards, was again composed of 1,250 h.p. With regard to the question of producing nitrogen from the air, that question had been raised by Colonel de Lotbinière, and the conclusion come to was that it would be too expensive. The idea was to produce cyanamide, a combination of nitrogen with carbon, but at that time carbon could only be produced in India at great expense, owing to the lack of coal. Since that time coal-mines had been developed in India, and cyanamide, which would be an exceedingly suitable fertiliser for certain soils in India, might well be produced there. It was noticeable that all the plants which supplied large powers in India were in the hilly or mountainous districts, where they required electrical transmission to a considerable distance and at great cost, and he thought there were water-powers in the lower parts which could be developed. He had been connected with one, but there the power varied greatly, and in the dry season only about 400 h.p. would be obtained, which might be sufficient to supply towns with light and power to work the trams, but would not be sufficient for supplying the factories at that locality all the year round with the required power. Some

system might be arranged by which the high-fall power plants in the hilly districts could supplement the installations in the lower districts when necessary. In one case in Switzerland a plant that produced 55,000 h.p. under high fall supplied current to another plant about sixty miles off, where the fall was only about 30 ft., the two systems together supplying a large industrial district with power. Some method of that kind might be adopted with advantage in India. With regard to high falls, the question was often asked as to what was the highest fall that could be utilised in one stage. At one place in Switzerland turbines had been installed that utilised a fall of 5,000 ft., and the same might be done in India, but for such a tremendous pressure pipe-lines were required that could not be produced in the ordinary way. With reference to the fact mentioned in the paper that power was supplied in Bombay at ½*d*. per unit, it would be interesting to know what the capital outlay per horse-power delivered at Bombay would be, because the charge of ½*d*. per unit was remarkably low.

Major-General Beresford Lovett, C.B., C.S.I., said he would like to know why the author dismissed the very successful scheme of electrification at Simla in two lines and yet devoted several paragraphs to the Mussoorie scheme. Moreover, there was no mention in the paper of the Darjeeling scheme and other schemes which were in operation at the present time; and, with regard to prospective schemes, nothing was said about the Jumna scheme, which proposed to supply Delhi with electric power, or alternatively to work iron-mines within a mile of where the proposed central station was to be.

Sir Murray Hammick, K.C.S.I. (Member of the Council of the Secretary of State for India), proposed a vote of thanks to Mr. Dickinson for his interesting paper, and to Mr. Moore for reading it. With reference to Mr. Burlton's remarks, in which he cast rather a slur on the Madras Presidency for not having electrified the Nilgiri Railway, and said that the Kateri Falls should be used for the purpose, apparently Mr. Burlton was ignorant of the fact that those Falls were already harnessed for the very large cordite factory that had done such splendid work during the war. The Kateri Falls had been harnessed for several years, and supplied the power to run all the machinery of that great cordite factory. He knew that the electrification of the Nilgiri Railway had been on the *tapis* for a very long time, but a great scheme such as that required a great deal of consideration. Another large scheme in Madras was connected with the Periyar works, and there now appeared to be some prospect of its being carried out. It was an extraordinary thing that the immense fall of water that came down from the splendid irrigation lake at Periyar had never been used for the production of power. He felt certain that, as the outcome of the energy displayed in the matter by Sir Thomas Holland, the Government of India would seriously undertake the thorough hydrographic survey of the whole of India with regard to electric power which had been wanted for so many years past. The ignorance of the hydrographic conditions of India had stood in the way of all the schemes that had hitherto been brought forward, and those who had travelled from Madras to Bombay would appreciate the tremendous amount of power that was being wasted on the ghats—a waste which it was hoped might soon come to an end.

Sir Francis Younghusband, K.C.S.I., K.C.I.E., in seconding the motion, said the paper was a very interesting and valuable one, and ought to have a great effect on the future development of India. He hoped the meeting would endorse the proposal made in the paper that there should be a thorough investigation made of the water-powers of India—a proposal which had already been endorsed by the Chairman and Sir Murray Hammick. It was exceedingly important that such a survey should be made, because of the tremendous possibilities which lay before India in the development of its water-power. He was Resident in Kashmir at the time when Colonel de Lotbinière carried out his great work of installing electric-power on the Jhelum River. He had many conversations with him with regard to the development of water-power in India, and Colonel de Lotbinière pointed out the possibilities latent in the water-powers of the Himalayas. The present paper referred chiefly to the water-power from the ghats in Western India, but, of course, in the Himalayas there were even greater potentialities. Any one who had seen the great rivers coming down from the Himalayas would feel appalled at the idea of tackling such tremendous torrents, but only a few days ago he was reading in an American engineering journal of a scheme which had been put before the New York State for harnessing the Niagara Rapids below the Falls, the idea being to spend no less than £20,000,000 in making a dam right across the river and obtain 2,500,000 h.p. from that. No more difficult scheme than that could be undertaken in the Himalayas, and to tackle the Indus itself would not be a greater task than tackling the Niagara. If the great rivers that flowed down from the Himalayas could be harnessed, the railway systems which ran along the fertile plains at the foot of the mountains could be electrified, and power could also be provided for the electro-chemical processes for the ironworks and great factories that were springing up in India now. It was, therefore, exceedingly important that the Government should undertake a systematic survey and investigation of the water-powers of India, not only in the Himalayas but in the Western Ghats, in Central India and in Assam. If that could be done without delay, then private enterprise, both in this country and in India, could set to work on the task of utilising the water-powers of India.

MR. E. S. WOOLLARD MOORE, in replying to the discussion, said that, in reference to the question raised by the Chairman as to the meaning of the statement that the catchment area was exceptional to the extent that almost all the water falling ran off, the author meant that the water found its way from the catchment area into the lakes and did not percolate away or become dispersed in the ground. As to why the yarn was better when the motive power used in its production was electricity, he thought the reason was that the electric power gave greater uniformity in driving. With regard to the point raised that the author had omitted to mention many important schemes, it was stated in the paper that he only dealt with those that had come more or less within his own knowledge, and further a good deal of matter sent home from India had not arrived. It was stated in the paper that the Tata scheme at Khopoli was earning a profit of over £190,000 per annum at ½*d.* per unit, which showed that the capital expenditure was not incommensurate with the results that had been achieved. As to Niagara Falls, he believed the two power-houses on the American side and the one on the Canadian side had a present aggregate of about 285,000 h.p. The height of fall at Khopoli was not unique, but although there were higher falls harnessed, their installed loose power was less. Nature had been kind to the Khopoli scheme in providing a site for the forebay at a height above the power-house of some 1700 ft. only about 2½ miles distant. He was glad the Chairman had mentioned the paper read by Mr. Tuckwell on January 17th, because that paper gave records which were of historic importance. It might be of interest if he stated that the aggregate horse-power of the three schemes of Messrs. Tata—the Khopoli, the Andhra Valley and the Koyna River schemes—was over half a million continuous horse-power, or about one million horse-power on a ten-hour day basis. The Khopoli scheme was actually at work, the Andhra Valley scheme was in course of construction, and the Koyna River scheme, the largest of them all, was being closely investigated and studied. Their capacity exceeded the aggregate horse-power of steam turbines installed at the present time in the whole of the United Kingdom, and was practically equal to one-tenth of the aggregate horse-power of all kinds of power-engines in the United Kingdom. It was somewhat difficult to realise what such huge super-power stations meant. Taking a station of 300,000 h.p., such as the proposed Koyna River station, if that were a steam station operated for twenty-four hours per day with the best efficiency turbines and steam-plant that engineers knew of at the present time, it would need 30,000 to 35,000 tons of good quality coal per week, and as all the coal raised from a mine would not be suitable for power-house consumption it would not be unfair to say that a steam station of that size would require the output of at least two modern collieries. As the price of coal in India was rising faster than the interest on capital was rising, the disparity between water-power development and steam-power development was rather tending to increase. He thought that coal could be more usefully employed in the development of industry in India in the way of actual direct manufacture than in the production of power. Another point of comparison was that the storage capacity for a 300,000 h.p. steam-station in the matter of coal was a point of considerable importance when coal was being used at the rate of 35,000 tons a week. The amount of ashes that would have to be disposed of would be about 5,000 tons a week. The condensing for a station of that size—a problem far more difficult in the tropics than in a temperate climate—would require about 25,000,000 gallons of water per hour, which was the flow of quite a large river. So that the comparison between water-power and steam-power in India seemed to tend enormously in favour of water-power, and cheap water-power for India was no idle dream, but a realisable proposition.

The resolution of thanks was carried unanimously, and the meeting terminated.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 17th, 1918; J. AUGUSTUS VOELCKER, M.A., Ph.D., Member of the Council of the Society, in the chair. The paper read was "Agricultural Machinery," by FRANK STUART COURTNEY, M.Inst.C.E., Consulting Engineer to the Royal Agricultural Society of England.

The text of the paper was printed in last week's *Journal*. The following is the discussion on the paper:—

DISCUSSION.

THE CHAIRMAN (Dr. J. A. Voelcker), in opening the discussion, said the author had dealt with the subject in a very comprehensive and interesting manner. It would be a matter of satisfaction to all members of the Society present to hear that the Royal Society of Arts was the first to offer prizes for agricultural machinery, and that as long ago as 1812 it offered a medal for a reaping-machine. When the Royal Agricultural Society was founded it took over that work, and trials of agricultural machinery were now being conducted by that Society, of which Mr. Courtney had been for many years the Consulting Engineer. The author had described the history of the development of agricultural implements, and it appeared that he thought for ploughing land the steam plough would still take a lot of beating, despite the advent of motor ploughs and tractors. There were three or four points in the paper that had especially struck him. One was that there was a great deal of good in old things. When one saw that wooden ploughs were still used in some parts of

the country one felt there must be some good reason for it. Then a number of old things that had been discarded had been brought up again, as, for instance, the double-furrow plough. There had probably never been a time when the double-furrow plough had come into such extensive use as during the past year, when so much land had had to be ploughed up. Next he had been very much struck also by the new implements that had been invented, such as the disc cultivator and the disc plough, and which had done really wonderful work in turning up old grass-land. Lastly, he noticed that agricultural machinery had not, as yet, been brought to a state of perfection, as was instanced by the fact that at the present time there was not anything like a perfect farm-yard manure distributor. It was very difficult to understand the reason for one kind of implement being used in one part of the country and another kind in another part. Taking, for example, one point to which the author had referred, the methods of elevating hay: in the south of England the hay elevator was universal, but in the north the Marston fork was always used. He had had many discussions with his agricultural friends in both the north and south of the country as to the reason for this, but had never yet been able to find out the real cause. It would be very interesting to know whether there really was a reason, or whether it was merely the outcome of custom. All these points led to the general conclusion that in the future there would be renewed interest and importance attaching to the trials of agricultural implements, and he was sure that both the Royal Agricultural Society and the Royal Society of Arts would play their part in encouraging the development of agricultural machinery.

Professor William Somerville said that the war had caused special attention to be paid to agricultural machinery during the last few years. He served on the Agricultural Executive Committee of the County of Oxford, and the task put before that Committee by the Board of Agriculture of finding a certain number of thousand acres of newly-ploughed land would have been a great deal more difficult if it had not been for the advent of the tractor plough, the value of which was still under-estimated by many people, but which, in the hands of good workmen and used on reasonably suitable ground, did marvellously good work. With regard to the double-furrow plough, he remembered that twenty-five or thirty years ago that plough was very little used, but it had recently been very much developed. To comply with a ploughing order served upon him in a county in the south of England, he had purchased a double-furrow plough, which had done very satisfactory work. With reference to the remark made by the Chairman about one implement being used in one part of the country and another implement in another part, he thought the climate had something to do with the fact that the horse fork was used in the north of England and the elevator in the south. In the south the hay could more frequently be carted straight out of the wind-row, and in many cases, by means of hay sweeps, could be brought right up to the foot of the elevator, pitched on to it, and taken up to the stack with a minimum of trouble; but in the north the hay was rarely in such good condition as to be taken straight out of the wind-row on to the stack. He used to doubt whether there was any truth in the stories one sometimes heard about the spontaneous combustion of hay. In 1911 he put basic slag on to his land, which stimulated a great mass of clover, and the hay was probably carried rather too early, having regard to the clover. Possibly the horse fork dropped it in rather large lumps on the stack and it was not spread out quite as much as it should have been, and the hay sweep he used probably took up a certain amount of old herbage. The result was that the hayrick of fifty tons caught fire and the hay was all destroyed. There was a north-country implement that he introduced into Sussex about four years ago, which was most useful, but it had never been seen or heard of before in the south—*i.e.* the turnip-cutting cart. The cart was filled with roots and as the horse moved forward the turnips were cut into "fingers" and spread all over the pasture. In the north of England there was hardly a farm that had not got one of those cutting carts, yet they were absolutely unknown in the south, although they seemed to be just as suitable there.

Mr. James Falconer said that, as a member of the Implement Committee of the Council of the Royal Agricultural Society, he took a great interest in agricultural implements. With regard to Professor Somerville's remarks about the turnip-cutting cart not being used in the south of England, it was well known that farmers in the south were not very ready to adopt new implements; they had to be thoroughly convinced of their usefulness before they would begin to use them. The turnip-cutting cart in Scotland, and in some parts of the north of England, was very largely used to cut the turnips for sheep feeding on grass, but there were very few sheep fed on the grass in the south of England, and that was probably one reason why the turnip-cutting cart was not so much used in the south. With regard to double-furrow ploughs, he well remembered double-furrow ploughs of the Pirrie type that he had about thirty years ago, and similar ploughs were made by both Scotch and English makers. They were a totally different kind of plough from the double-furrow ploughs of the present day, and were far too heavy. The reason why the double-furrow plough was not used in Scotland to the same extent as it was in the south, where it was absolutely universal, was owing to the amount of cartage that had to be done on the farms in Scotland. It was found that, by putting the horses into three-horse teams, when the time came to cart turnips, which in

Scotland were generally pulled and stored in the autumn, the man, who had to give up his horses to make a three-horse team and go to do odd work, refused to look after them, and would have nothing to do with them when he was told to cart turnips. The consequence was that farmers in Scotland reverted to the single plough, each man with his two horses, and he thought that practice was likely to continue. He introduced the double-furrow plough into the south of England twenty years ago, because he had seen the advantage of it in the New World. In New Zealand twenty years ago he had seen the double-furrow plough worked with four horses, every man ploughing four acres in a day of about eight hours. In the New World machinery was far more largely used than in England or any other part of the Old World. When he visited France about six weeks ago he saw at one farm a man thrashing with a flail, and at another farm of 520 acres he saw a four-horse thrashing-machine of the kind used when he was a boy, and in neither case was the corn thrashed clean, a great deal of it being left in the straw. Probably the reason why English farmers were so slow in adopting up-to-date machinery was that the wages they used to pay their men were so extremely low, and they did not need to use machinery to any great extent because they could employ such a large number of men. In the New World, on the other hand, wages were very high, and the farmers, therefore, adopted machinery to a very great extent. Personally, he had been convinced of the great advantage of up-to-date implements when he was managing some sugar estates in the Sandwich Islands, the directors of the company insisting on the adoption of all the latest machines devised to save labour. When he first introduced the two-furrow plough in the south of England he was the laughing-stock of the country, but now it was in universal use, and had been a great blessing during the war owing to labour being so scarce. It was scarcity of labour that had been the means of inducing farmers to employ more machinery; they had begun to realise the advantage of it, and would do so more as time went on, because wages would be very high after the war. One implement that he heard about in the Colonies was the four-horse drill, which was still seen in some parts of England, entailing the use of three men and four horses. A neighbour of his had had one, and on one occasion they started to sow barley on the same day in two fields alongside one another, of the same size and composed of similar land, and, using one man and two horses, he had finished the work before his neighbour with three men and four horses. With regard to thrashing-machines, in Scotland almost every farmer had his own up-to-date thrashing-machine in his farm buildings, using either turbine wheels or oil engines. They thrashed a certain amount every week for the stock, thus being able to give them fresh straw, and another advantage was that everything was kept under cover. In his opinion the two-engine steam plough would never be done away with, although no doubt the tractor had come to stay; and there was a great future before electricity as applied to the driving of agricultural machinery.

Mr. W. J. Malden said the author had taken the responsible part in the competitions organised by the Royal Agricultural Society, which had done more than all other influences to further the use of agricultural machinery. With regard to the Chairman's remarks about the elevator, he thought the reason of its popularity in the south was that it was much more convenient to take the sheaves of corn on to the stack with the ordinary elevator than with a fork. Hay could be taken up quickly enough with a fork, but it could be got up rather more easily with an elevator with an oil engine attached to it. With regard to double-furrow ploughs, he had tried them on hard ground and found it very difficult to make them enter the ground at all, and he thought that was one of the reasons why they are not so popular as might be expected. Having two points to strike the ground, if one struck the ground there was another one to knock it out. On very hard ground it was all a good ploughman could do to make a single-furrow plough enter. On easy ground, however, he thought they were to be preferred for some kinds of ploughing.

Mr. Alfred Hicks wished to emphasise the remarks made at the end of the paper with regard to the standardisation of machines. The author suggested that each district should settle what type of machine it wished to adopt. In examining the price list of a leading firm he found no less than thirty-three ploughs catalogued, and he maintained that that number should be greatly reduced. If there were only six instead of thirty-three, he could obviously buy his ploughs much more cheaply and quickly. He thought that scientists in conjunction with the Agricultural Society should settle the most suitable form of machines, and not the various districts. At the present time he thought a great deal of agricultural machinery was much too heavy. He had a disc harrow which he would like to use, but it was so massive and heavy that he could not do so, and he thought scientific men ought to try to devise agricultural machines with less weight. It might be of interest if he stated a fact that probably many farmers were unaware of, that each farm horse took five acres of the farm-land to maintain it for a year. He had been very much surprised when he first read that, but had worked it out and had come to the conclusion that it took five very good acres to keep each horse.

Mr. John Allen, O.B.E., said he was principally interested in cable ploughing. At the present time there were cable ploughs working with internal-combustion engines, and he had recently seen a small set doing very good work. With regard to tractor ploughs, no doubt they had come to stay, and eventually direct traction would be used very considerably on the lighter soils, but

there were serious limitations to its use. In this country there was a great deal of heavy land which was the best for wheat-producing, but owing to the climate it was for a considerable portion of the year either too wet or too dry for tractor ploughing, and he therefore did not think direct traction would ever be successful on the heavier soils. As to the method of conveying power from the surface of the ground to the drawbar, the caterpillar method was the more practical, provided the heavy tear and wear on the chains could be overcome. The difficulty of lubricating the joints and pins under such conditions would appear hopeless. Possibly, with experience, some improved method would be devised. The direct wheel drive was much simpler. It was surprising that some makers of tractors were reducing the diameter of their wheels. His experience was that six inches in the diameter of ploughing engine wheels made all the difference in getting along on soft ground. The American tractor of to-day was a crude machine, with a very short life. Tractors of the future would require to have a longer life, but whether this could be accomplished without seriously increasing the weight was a problem. What was really required in a tractor was the highest power with the minimum weight, provided there was sufficient weight for adhesion. With regard to ploughs, he remembered that some forty-five years ago in the north of Ireland the Oliver plough was introduced, and all the farmers there that adopted it thought it a fine thing, but it gradually went out of use. In the same way he did not think English farmers would continue to use the ploughs with short mould-boards that just threw the soil over. The metal in the American mould-boards worked cleaner than the English steel. This he had proved from experience with an English-made plough, in Dakota, years ago. He was of opinion that the future of the cable plough was assured. The cable plough was at its best when pulling a cultivator, as not much more than half the power of a modern ploughing engine could be absorbed when pulling a plough, in medium soil, for the reason that the plough could not be handled if made large enough to absorb the full power. Such modern ploughing engines gave over 100 b.h.p. This power was required for handling the heavy high-speed cultivator in use to-day. The cultivator was, and always had been, the premier mechanically-propelled implement in this country. The beneficial results of cultivation were due to the high speed at which the cultivator travelled, breaking the land up in large pieces, leaving it open for the sun and air to penetrate, whilst after wet weather it dried off much more quickly. A heavy cultivator was required to run steadily and maintain equal depth. It was not uncommon for between thirty-five and fifty acres to be cultivated in a day with a large set, under favourable conditions, with a low consumption of coal. He had known over sixty acres covered in a day. The author had mentioned the economy in coal effected at the last portable engine trials of the Royal Agricultural Society, which was certainly very remarkable, but those were racing trials. He had made various tests of up-to-date compound engines in the fields, and found he could not get the horse-power for anything like the consumption of coal mentioned in the paper. If the internal-combustion engine could be stopped and re-started easily, and made more flexible, it would be more convenient than steam, but he doubted whether the actual fuel costs could be brought down to that of coal and water.

Mr. F. S. Courtney, in reply, said he quite agreed with Mr. Allen that the steam plough would plough where it would be impossible to attempt to work with a tractor. With regard to coal consumption, he did not think that with judicious firing and a good man who was used to his work the losses caused by the engine standing half its time would be so great as might appear at first sight. The coal consumption would compare favourably with that of oil in an oil engine, apart from the difficulty in the re-starting of the oil engine. With regard to the standardising of machinery, when he used the word "districts" he did not mean districts in the sense of counties, but the north of England, for instance, as opposed to the south. There were places where one kind of plough was better than another, and in those places it should be decided by the users of the machinery there, in consultation with scientific men, what kind of machines were most suitable. A plough-maker had told him recently that there were about two hundred different patterns of ploughs, but less than seventy of those were marketable things. If the number could be reduced it would be of benefit to both the manufacturer and the user. It would reduce the cost and facilitate output, and would also save an immense amount in the maintenance of spare parts.

On the proposition of the Chairman, a vote of thanks was accorded to Mr. Courtney for his interesting paper, and the meeting terminated.

OBITUARY.

Alfred Gordon Salamon.—Mr. Alfred Gordon Salamon, who died on April 9th at the age of fifty-nine, had been a member of the Royal Society of Arts since 1887. In that year he read a paper on "The Purity of Beer," for which he received the Society's silver medal, and in 1888 he gave a course of Cantor Lectures on "Yeast, its Morphology and Culture," which did a good deal to make known in this country the classical work of Hansen. He contributed a number of papers on experiments in malting to the *Transactions* of the Institute of Brewing (of which he was President in 1907), and papers to the *Journal* of the Society of Chemical Industry on the influence of phosphates in fermenting

worts, and on the manufacture of caramel. He was also interested in the manufacture of cyanides and of artificial perfumes. At one time he had a large practice as a brewers' analyst and consultant, but latterly he devoted himself more particularly to general technical chemistry, especially in its legal aspects. He was for two years chairman of the London Section of the Society of Chemical Industry, and he also took much interest in the work of the Institute of Chemistry, of which he was honorary treasurer up to the time of his death.

Edward Alan Christian.—Mr. Edward A. Christian, who had been a member of the Society since 1908, died on February 17th. He was born at Milntown, Isle of Man, in 1879, and after being educated at Christ's Hospital, he spent some years in various countries on the Continent for advanced study in electrical engineering.

In 1897 he started upon practical electrical work under Mr. Shaw, engineer and manager of the Isle of Man Tramways and Electrical Power Company. In 1903 he entered the service of the Mersey Railway, Liverpool, as rolling-stock engineer, in which position he took an active part in the inauguration of the new service, and in 1909 he was advanced to the position of assistant engineer. In 1915 he was obliged, through illness, to return home to Milntown.

He took a deep interest in social matters connected with the Mersey railway staff, being vice-president of the benevolent society and the athletic and social club.

Mr. Christian was the last male survivor of an ancient and prominent Manx family, the Christians of Milntown. They are first named there as far back as 1100, and they have held the estate of Milntown in unbroken succession from father to son since 1400. In early days the Deemstership was an hereditary office in this family, and since then rarely a generation passed without one of their members—often father and son together—filling that office, Mr. Christian's grandfather having been the last Deemster Christian.

GENERAL NOTES.

Destruction of Food by Rats.—In a letter addressed to farmers, and circulated officially, Viscount Chaplin and Lord Lambourne (formerly Lieut.-Colonel Mark Lockwood, M.P.) make an urgent appeal for the adoption of all possible means to rid rural districts of the brown rat, "an underground enemy, who destroys our food supplies almost as much as the submarine." It is pointed out that in 1908 Sir James Crichton Browne estimated the yearly damage done to food by rats, in England alone, at £15,000,000. The value of that quantity of food to-day would be nearly £40,000,000. In the rush of work on the farm, which has to be done with diminished labour, rats have multiplied. The rat will breed when four months old, and has from three to five litters in a year. Her average litter is ten, but as many as twenty-three have been found in a nest. On a moderate estimate, the English countryside is feeding one rat per head of the total population of these islands, and ten rats will, apart from what they spoil, eat a quarter of corn every year. Attention is called to the advice given in a Board of Agriculture leaflet (No. 244).

Cannel Coal.—The Ministry of Munitions has been asked in the House of Commons to state how many modified plants for the distillation of petroleum from cannel coal are now in operation at gasworks in Great Britain, and what production has been obtained up to the present. The Parliamentary Secretary to the Department, while declining on public grounds to give details of production, said that gasworks in Great Britain are either now modified, or in course of modification, to enable all the cannel coal which is known to be available to be carbonised for the production of oil. He added that the process so far has been an unqualified success, and that the results were even better than were expected.

Water-power in Spain.—In the Spanish Senate on May 3rd Señor Cambo said that the Government is occupied with a large scheme for the development of hydro-electrical energy, and he more than hinted at the existence of a plan for working thus the main railways of the country. According to the special correspondent of the *Daily Mail* in Madrid, practically all hydro-electrical plant in Spain is run with machinery supplied by Germans whose "usual commercial forethought has been displayed in a systematic cultivation of the subject as well as in a good deal of surveying and buying of properties where this power could be developed on a large scale." There is said to be enough water-power in Spain "to do the whole work of the country." The correspondent points out that the industrial development of Spain is "hung up for lack of communications and transport," the latter at present depending on coal.

Indian Hides for Canada.—According to information laid before the Imperial Institute Committee for Canada at a recent meeting in London, under the chairmanship of Sir George Perley, High Commissioner for Canada, great interest is being taken by Canadian tanners in the representative collection of Indian cowhides which was despatched to the Dominion by the Hides and Tanning Materials Committee of the Imperial Institute. The collection is being exhibited at various centres under the auspices of the Canadian Ministry of Trade and Commerce, and several inquiries have already been received from Canadian firms as to supplies of the hides. It is probable that as soon as the Government restrictions on the disposal of Indian hides are relaxed, a considerable trade will be done direct with India.

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FRIDAY, MAY 24, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK.

WEDNESDAY, MAY 29th, at 4.30 p.m. (Ordinary Meeting.) MARTIN O. FORSTER, D.Sc., F.R.S., Treasurer of the Chemical Society, and a Director of British Dyes, Ltd., "Organic Chemistry in Relation to Industry." SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., will preside.

PROCEEDINGS OF THE SOCIETY.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 24th, 1918; The RIGHT HON. LORD SYDENHAM, G.C.M.G., G.C.I.E., G.B.E., F.R.S., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Brown, Joseph Pearce, J.P., Plymouth.

Kingsford, William Edward, Cairo, Egypt.

McConnel, John Wanklyn, M.A., Manchester.

Ramsay, Alexander, Lincoln.

The following candidates were balloted for and duly elected Fellows of the Society:—

Barrett, Frank, Grimsby.

Campbell, Oliver Hering, London.

Chopra, Igbal Chand, India.

Cobbett, Colonel George Talbot Burrows, London.

Cockill, Harry, Southport.

Davies, Frederick Herbert, London.

Dickie, James, Ayr.

Dobson, D. Bennett, Thames Ditton.

Feltoe, Rev. Charles Lett, D.D., Dover.

FitzGerald, Francis William, London.

Forbes-Bentley, Lieutenant Rupert, R.N., Beckley.

Harrison, Joseph, Hon.A.R.C.A. (Lond.), Nottingham.

Hugh, James, Bothwell, Scotland.

Ishii, Shinji, London.

Lathe, Alfred, Bilston.

Nisbett, G. H., M.I.E.E., Liverpool.

Reddan, William Holmes, Mansfield.

Singer, Edgar Ratcliffe, Frome.

Statham, Noel, New York City, U.S.A.

Tuck, G. O. Kentucky, U.S.A.

Underwood, Oliver, London.

Watson, Charles Edward, Wall, North Tyne.

The paper read was—

THE MENTAL EFFECTS OF THE WAR AND THEIR LESSONS IN REGARD TO MEDICAL AND SOCIAL RECONSTRUCTION.

By MAJOR SIR ROBERT ARMSTRONG-JONES, M.D., R.A.M.C.

It has been truly said that the most eventful as well as the most interesting period of a nation's psychology is that during which its people is passing through the crisis of war, and in his search for a moral equivalent for war, William James, speaking as a psychologist, stated that the martial type of character might be bred without war. He expressed his belief that the military temper might find a substitute in an imperative and obligatory service to the State, and he remarked that some professions, in particular those of the priest and of the medical man, were in a fashion educated towards this type; for they were taught to show strenuous honour and to practise disinterestedness in the war against disease, poverty, and sin; but in an imperfect world we know that the military temper and the martial spirit are means to an end, and they are bound to be some

of the means by which the ideals of self-sacrifice, social justice, liberty, and human brotherhood may be defended. Grotius has said "War is waged for the sake of peace," and it would show a shrinking from responsibility and a craven spirit if these ideals should pass undefended because of the suffering involved, or the carnage inflicted, or because of the risk of loss of possessions or of treasured achievements which war might bring about. We have entered upon this war for ideals, and we hope not to sheathe the sword until these have been secured for the weaker nations struggling to be free.

The war has now lasted over three and a half years, and is without any immediate prospect of cessation. It has disturbed the mind and altered the course of thought of whole continents, and out of the great cataclysm of human struggle it is fervently wished that a better world may emerge. It is within the scope of this Society, founded in 1754, to consider any prominent subject dealing with the life or the health of the people, with its social habits, as well as with the production and organisation of its commerce, and any scheme of "reconstruction" after the war must find an encouragement in the support of the Royal Society of Arts.

As this paper purports to deal with the mental effects of the war in their wider application, it may be pardonable if it is remarked that in normal health the mind acts as a whole; the action of the nervous system being described as of the syndromic variety; but under abnormal, or unusual conditions, the effect of any great psychological stimulus is to create a dissociation of the mind as a unity and to cause its various elements to become severed or disconnected, so that self-control and inhibition, for instance, which are characteristics of the higher man, tend to become impaired or even to disappear, the emotions to become intensified, and the will to lose its domination so that actions become impulsive and irrational. The great lesson of the war has been to show that man, in his mental build, is a co-ordination of many primitive instincts, feelings, and actions, which have gradually been built up and correlated for the benefit of the whole. In the primitive amœba, such as paramœcium, we find that, although each cilium contracts independently, they are all co-ordinated to act in a very definite and rapid sequence so as to produce the movement of the whole animal, yet the effect of certain reagents applied to the cilia is to bring about irregular and dissociated contractions. The same results may be seen in the contractile umbrella of the jelly-fish, for although each group of nerve cells controls a particular area of the umbrella, they are all so well co-ordinated normally that the bell contracts as a whole and with a proper rhythm. Precisely the same analogy pertains to human beings: the mind normally acts as a whole and in a unified scheme for the benefit of each individual, just as individuals unite together in a well-ordered social group for the common good; but when any inordinate stimulus is experienced by the group or by any of its constituent parts the tendency is towards a dissociation or to a want of balance of the whole. In certain individuals the effect of the war has been to produce a dissociation of some of the elementary constituents of the mind, and these have either over-acted in the presence of others or they have been suppressed. It is a fact of experience that during this war a special strain upon the mind through the over-action of one element has brought about a disintegration of the whole; and it follows from this dissociation—and it is helpful in securing restoration—that any factor which contributes to the welfare or to the improvement of one element also contributes to the improvement of the whole mind.

War-shock or shell-shock has demonstrated fully the dissociative effects of a great emotional strain upon the mind, and, secondarily, upon conduct, and this has occurred in many thousands of instances. This mental abnormality is in all probability the result of the emotion of *fear*, which man has experienced and recognised from the earliest stage of his evolution, and it is one which he has tried most to avoid and to control, lest it should seize his whole personality. The fear of solitude, of being without protection, of vast distances, of open places, of closed spaces or of great heights, and of darkness, are notable instances of this occurrence of the emotion of fear, which may be revived under stress or through unusual conditions. One of the most common manifestations of this feeling of fear in our sick soldiers has been muscular trembling and a motor inco-ordination varying from very mild shakiness to general convulsive seizures bordering upon epilepsy, and which, in so many instances, has been most difficult to relieve. It is without doubt that fear is the most powerful stimulus that can be applied to effect a muscular discharge, for the purposive end of fear is to cause flight and to ensure safety; but in the combat of war the duty of the soldier is to stand his ground and to defend himself and his country against aggression and

attack. It is only when the natural and instinctive feeling of fear unconsciously collides with the higher developed duty of the citizen that a conflict occurs; an intense effort is made by the higher centres to suppress this primitive fear; after a long struggle the effort at suppression fails, and shell-shock results. Should the victim of this mental conflict be wounded the wound provides a more ready diversion for his thoughts and an easier channel of outlet for his pent-up emotion, and he rarely then becomes the subject of mental dissociation. It must not be assumed that shell-shock cases are wanting in courage. They are often the most sensitive and brave and adventurous. Cases are known among the most seasoned soldiers of the old Army and even in a V.C. For his restoration it has been found by experience that new interests and a cheerful confidence amidst natural surroundings provide the best means to recovery, and, fortunately, if only the lead is given, there are many persons in civil life both willing and ready to offer this necessary help, which may, perhaps, best be described as a cure by the "return to the land."

The psychology of the war has brought us into contact with life in a manner that no national upheaval has ever done before, and the emotions have been kindled in a way never previously experienced. There has been among the civil population an excitement or a mental erethism that has caused the emotion of disgust or anger to be most unreservedly expressed. Especially is this the case in regard to the barbarous and inhuman cruelties imposed by the Huns upon the vanquished: women have been outraged and children murdered and mutilated. The soil of Belgium has been drenched with the blood of martyred hostages, and we ourselves know what has occurred to the devoted Nurse Cavell, to Captain Fryatt, to the "Lusitania" and to our hospital ships; the emotions of horror and disgust have been loudly expressed over these revolting cruelties, but hope and the tender emotions have not been omitted; the love of home, of patriotism, and the feeling of pride in our race have been kindled and the world of idealism has been roused to a degree never before witnessed. The war has certainly brought the emotions into greater and clearer relief and has given us all a much wider psychic experience, and one experience within the range of everyone is that "privilege" during the war has been vastly curtailed and "equality" rules in social conditions, for every person in the kingdom is, or soon will be, in the same position with respect to his daily food; the richest man in the richest city is no longer able to indulge his desires. He cannot choose what he will have for dinner; owing to the acute disturbance to domestic labour he cannot enjoy the services he formerly commanded; he is unable to travel except by motor-bus or underground, for a taxi may not be available; and he is unable to meet his friends, for his friends cannot entertain him, or they are engaged in doing work of national importance. This state of things is bound to leave a permanent memory and to mould the character of the young and to show them one great lesson, which is the need to work and the continuous necessity there is to be careful and sparing in the national interests.

The changes that have already taken place in the habits and social tendencies of the people are enormous. In the absence of an overwhelming sorrow and anxiety everyone now talks of rations; and of all interests, probably housekeeping is the most absorbing; the eternal topic is household management. Cooking receipts, house-cleaning, and dressmaking command more interest now than ever before, and who will say that these are not of distinct benefit to the country, for in consequence there is less waste of food and more variety, and it is more carefully prepared. As a housekeeper says, a pennyworth of rice has to go farther to-day than a sirloin of beef went before the war, and every home in the land is better for the lessons thus compulsorily taught in domestic economy. Most young women and many wives and mothers are to-day offering their whole strength to the nation, and their great aim when they return home is to learn how far their food will go, how they may dress without extravagance, and how the home can be kept clean with fewer servants. Thrift has also received a marked encouragement. Before the war little or no interest was taken by mothers or by children in the savings banks, as "it wasn't worth while." Now, most families are capitalists owning war certificates, and the use and value of saving small sums has been realised by every person. In every town and village, even in the large cities, the men, women, and children are awake to the fact that scarcity of food may merge into famine, and they have been busy during the seasonable months of the year in cultivating allotments; making the utmost use of every acre of fertile land, taking an interest in production, and talking about their gardens. More is known to-day by the masses of the people about the varieties of

potatoes and the best kinds of cabbages and onions for food than was ever known before, and instead of idle loafing and consequent discontent, the engrossing interest in their leisure has been over their crops or the care of their plots—not only to the great benefit of their bodily health, but also to the happiness and contentment of their homes. Barrows in the streets now provide seeds to sell for garden vegetables, and they are only supplying a demand created by present social conditions. It is not improbable that the "land" may completely solve the problem of undue attention given before the war to athleticism both by men and women, and it is not improbable either that the "land" may be the great solution of some of the problems confronting women after the war. It is estimated that there are twenty-five millions of men and women in this country, and each of them is encouraged to continue cultivating the land and doing his or her share. If a small plot of even one-tenth of an acre per person were used for potatoes, for example, it would give us two and a half million acres, which would be five times more than was grown last year, and in this way we should be helping to solve the shortage of food for at least another year.

It has been suggested by an eminent thinker and philosopher that what is required in social reconstruction is not only more material goods, but more freedom, more self-direction, more outlet for creativeness, more opportunity for the joy of life, more voluntary co-operation and less involuntary subservience to purposes not their own, and to obtain this he is ready for the destruction of institutions or of the established order of things in so far as they are hostile to the higher instincts and to the individual impulses of men and women; but the individual impulses of men and women are unreliable factors in true progress, although it must be admitted that both our individual and social life are dependent upon impulses and instincts whose nature and origin are primitive, but these have become modified through long periods of evolutionary development and through the influence of civilisation they have developed into highly organised and complex tendencies. It is these tendencies, and not the original instincts, that must be considered when dealing with the basis of reconstruction. Society, owing to the war, is in a state of flux, and we see the inadequacy of present arrangements in many departments. We need not only great wisdom, but also the will to act, for reconstruction is no longer a matter for philosophical speculation. An ineffectual yearning is a mere dreaming, and we need not only the will but also the courage to act. At the same time I am quite prepared to admit that our present vision of affairs is a partial one, because we have yet to know exactly how the war may end or whether the masses of the people will tolerate in peace time the restrictions imposed by the war. There may be a great rebound, and a great reaction may be in store for us after the war, associated with all kinds of mental, moral, and bodily excesses and indulgences, so that, in spite of the grave anxieties we have experienced, the war period may be contrasted with it even as a happy one.

We can all say that we have already watched the general trend of social movements, and we need to take to heart seriously and deliberately the lessons taught to us and to prepare ourselves for the legislation which is inevitable, and which many thoughtful people may even consider to be revolutionary.

I venture to think that there is one lesson taught by the war which will be of doubtful advantage—viz., that in the hurry and haste of war-work everyone has become more abrupt and less regardful of the amenities which were formerly considered to be the "salt of the earth," both in public and in private life. There is to-day less consideration for the ceremonies, conventions, and courtesies of social existence; but this is only a continuation of the feeling which began to make itself evident towards the close of the Victorian Era, and which has had the wholesome effect of extinguishing the "Cranfordian" tendencies that were both superficial and insincere. The question, to my mind, is whether the war has not caused a swing of the pendulum too far, and whether we shall not miss the kind word, the gracious act, and the considerate conduct which marked the dealings of men and women in pre-war days.

Church.

The mental effects of the war upon religious feeling in the country have been discussed in the lay press, as well as in Church circles, and the matter has been the subject of pulpit addresses; but up to the present there have been no marked religious developments in consequence of the war; in fact, it has not had the effect expected, viz., to remove the spirit of indifference which prevailed both among men and women before the war. A new atmosphere of purpose has certainly been

created by the war, but it cannot be said to have extended into the Church, although some few distinguished clergy have urged members to strike for freedom and to attempt to rebuild the national life in the spirit of liberty, justice, and enterprise.

There has been a desire on the part of some of those who minister to the spiritual welfare of the people, to see how the men themselves lived in the front trenches, and some few have taken combatant rank and have sacrificed their lives in the defence of their country's honour. The feeling kindled by common service and by common suffering in the trenches, and the experience gained in hospitals and homes, ought not to be without good results. It should become the basis of unity and good fellowship between different classes of men and between different grades of society, and it should supply the opportunity for urging a new spirit of sacrifice and citizenship in the days to come; but the stern discipline of war has so far not led men and women to turn their thoughts and minds to things spiritual, nor has the Church—which in the past has provided out of 20,000 schools about 12,000 in which secular teaching was combined with the teaching of religion—given since the war any special attention to the encouragement in the young of a law-abiding citizenship, which, in view of the great increase in juvenile delinquency, is a serious need. True, there have been the usual confirmation classes and Sunday schools, but little beyond these. It has been very different in America, where far greater efforts have been made, since the war, to increase the sense of fellowship; but we realise there must be in America a greater need for assimilating the influence of foreign immigrants.

The teaching of the Church is broad enough to include two aspects of social endeavour that may justify their consideration by this Society; one is the great question of intemperance, which was the greatest curse until it was strongly taken in hand by the Central Control Board (Liquor Traffic), and the other is the social disease whose ravages are so well known to the Chairman, and which have been so freely ventilated in the medical and lay press, and through the National Society for Combating Venereal Disease. These are two great and dark shadows that stand across the field of reconstruction, and the latter is now being taken up by the Army authorities. It should also be approached by the National Church, and could probably be most successfully overcome by the personal relationship between the clergy and the people.

The future prospects of the country depend upon the ideals that are implanted upon the rising generation by the various schools of thought represented among the clergy of all denominations. It would be the irony of an evil fate if the ideals we have fought for, and sacrificed so much blood and treasure to preserve, should fail to bring us spiritual comfort, unity and strength. The creation of new industries to replace those of war, and the preparation of the body and mind for the future reconstruction; the disintegrating cupidity associated with competition, and the social bitterness which is inevitable, are all conditions which the teaching of the Church should be brought to deal with; but the Church, as a whole, has held aloof from them up to the present. In a collection of essays by seventeen chaplains from the front, the general opinion is confirmed that the war has not brought a "revival of religion" as understood at home; but the war has created a mental effect which may best be described as self-surrender to a cause and self-subordination to the interests of a common purpose; and life since the war has certainly appeared to be of some purpose, even to the most careless and profane and apparently irresponsible. To these it has brought a sense of vocation and a feeling of common loyalty which must be recognised. The soldier believes his cause is right, and that it is his duty to see right triumphing over wrong, and he has come forward with others in a spirit of brotherhood to show his faith. Speaking psychologically, there is no possible doubt but that fellowship has been a reality at the front; it has existed between laymen and clergy, as also at the front between ministers of the various Christian Churches. Whether the lesson can be taken to heart and a great spiritual objective presented, bound by a common membership pledged to a common loyalty for a common end, remains to be seen. We find many different claims are being put forward, such as that for a more extensive modification of the Prayer Book, or for a more modernised catechism, or for more freedom to realise self-fulfilment and to enjoy a fuller and stronger social life, and it is certain that these are healthy signs, for they are put forward by thoughtful men with the single aim of spiritual betterment. The Archbishops of the two provinces have realised the need for more workers to direct the lives of those who are to replace the flower of our people, whose

graves have hallowed the soil on the various battle fronts; whilst others see the pressing need for spiritual influences to modify dangers from within as well as to avoid the bitterness of social unrest. It is for this reason appropriate that the work of the Church should be brought before this Society, which has always tended to improve the lives of the people, on the mental as well as on the physical side, by cultivating an appreciation for the arts, for science, and for a good literature to be placed before them. I need not say anything further to justify my placing the work of the Church in any scheme for social reconstruction.

Temperance.

One of the most striking lessons of the war has been in the direction of temperance reform, and this is a very crucial as well as a much-debated topic. It may be remembered that so serious had matters become six months after the commencement of hostilities, through drunkenness, impairment of health, loss of workmen's time, and general bad temper where a large population had congregated for munitions and other Government work, that the present Prime Minister described "the drink" as a worse enemy than the submarine, and in consequence the Liquor Traffic Control Board was instituted by Parliament in June, 1915, under the Defence of the Realm Act, with Lord d'Abernon as its chairman. He gave the matter his full attention, and he deliberately considered drinking continuously or at very frequent intervals, especially during working hours, to be at the root of the evil, and to be the proximate cause of most of the physical and mental disabilities among workers. The Board set out with a definite policy, which, speaking generally, was to stop continuous drinking and to discourage all drinking except at meal times. The results of the work carried out by the Board read like a romance, and it is only short of marvellous that the Regulations of the Board, which have the validity of an Act of Parliament, should to-day be controlling the lives and habits of 38 millions of people out of the total 40 millions which constitute the population of Great Britain, and all this without explicit Parliamentary sanction; but it must be noted that the Board has not acted in a single instance without an application to do so being presented by the local naval, military, munition or transport authority. Wherever the Board has exercised its powers, there the convictions for drunkenness have diminished by one half—from 159,000 convictions in London and forty large towns before the war to 77,000 in 1916 and to 45,000 in 1917. The streets have become more decorous, the station platforms more orderly, the people more tranquil, and crowds less excitable; the workers have been healthier and their minds less irritable; there has been more contentment among the mass of the people; they are more reasonable, and they have got through more work. These specific attainments of the Board have been testified to by chief constables, who record a diminution of drunkenness and disorderly conduct in England and Wales from 2,688 convictions a week in 1914 to 850 in 1917, also by medical officers of health, and by social workers; district nurses have similarly spoken, and even members of the licensing trade itself have expressed approval. This is a war-time measure only, yet its achievements and their lessons have left an indelible impression upon the country. No scheme of reconstruction can disregard the success which has attended the thoughtful and successful control of the Board over the drink traffic, for not only has the Board restricted the sale of alcoholic drinks, but it has also provided counter-attractions to the ordinary public-house business by recreation and entertainments, and it has also arranged postal and banking facilities for their customers. Before the Board was instituted, the former policy of regulation and restriction under private ownership had already received a full and fair trial; it had reached its effective limits and was found wanting. Thoughtful people are not likely to let the work of the Board be forgotten, it has meant so much to women and mothers and homes, and the women who have benefited will now, with the extended franchise, help to control the drink problems, and there must be no competition or quarrel or jealousies between temperance reformers about ideals which will only result in destroying what, by an overwhelming consensus of public opinion, has been the great lesson of the war.

Whether we should continue the limitation of output and what can be done to prevent the loss of revenue, or whether there should be State Purchase are questions of practical statesmanship in regard to which Lord d'Abernon must be the best authority.

The period of demobilisation may not be far distant, and, as has been wisely said, "Scenes of drunkenness will be a dishonour to a nation that has been fighting for right and righteousness." Our men will be returning home after most strenuous times, and there is bound to be some reaction. Those who have faced dangers,

and exposed their lives to so many risks for their King and Country, will feel that they are entitled to more ease and more material comforts than in the past, and the question of dealing with drink must be the first consideration. After the war there will be many social difficulties —many of these have probably been foreseen— but there may be destitution, shortage of food and money, and perhaps of employment confronting us; but one of the chief lessons has been the outstanding example of what has been done in regard to sobriety, and to ensure orderly conduct among the masses of the people, by Lord d'Abernon and his Board during the stress of war.

It remains to be seen how far, if at all, the country will ever wish to return to the periods of wild orgies, violence, and panics associated with intemperance, or whether there will be a response to the efforts made now to receive back our soldiers into a purer and more ennobling world. The young men of 1940, for instance, will depend upon what is done now for their mental equipment and physical vigour to enable them to compete successfully in the periods after the war.

CHILD LIFE.

Next in importance to the marvellous changes brought about in the habits of the people consequent upon the war, has been the fuller realisation of the pressing importance and the sacredness of child life, and the lesson taught is the precious care that should be exercised in its protection and supervision.

To most persons the war has been a great convulsive shock; but to parents it has brought measureless disasters, and to the State it has revealed at this crisis the supreme value of man-power, and the consequent duty imposed on the nation to care for the young. A declining birth-rate is a loss in power and prestige, and the loss of every potential citizen is a loss in creative power and in earning capacity. The birth-rate has been gradually falling ever since 1876, when it was 36·3 per 1,000, until it reached 22·0 per 1,000 in 1915—the lowest rate yet recorded, and a great loss to the country. Add to this the loss of life caused by the war, which implies not only a direct economical shortage but also an indirect injury, because the family has been deprived of its ruling and directing authority as well as its protecting and earning head. It is estimated that at least 100,000 children will be left fatherless owing to the war, and the orphans must be cared for as the Minister of Pensions has recently insisted. The orphans of our soldiers must be guarded against hunger, destitution and disease, because these are conditions which lower mental vigour as much as they impair bodily efficiency, and they tend to lessen the output of work of those upon whom in the future the country must depend for its proper place among the nations.

The loss of male life through the war has created the necessity for the employment in various capacities, and on a large scale, of many married women, and it has become a matter of supreme national urgency that the children should be cared for whilst their mothers are at work. Although we already have a large number of institutions of various kinds, *e.g.* small observation wards for slightly ailing babies, small lying-in homes for poor mothers, dental clinics for mothers and the children that are under school age, yet it is not generally realised that over 100,000 babies die every year in the United Kingdom; that out of 1,000 babies, 250 die either during the first year or during the ante-natal period. It seems an almost incredible revelation that out of 1,000 infants born, eleven die within the first hour, twenty-two within the first twenty-four hours, and thirty-six within the first month. These figures show the appalling loss of infant life that is occurring every day, and they call loudly for preventive measures for their arrest, and which the Maternity and Child Welfare Bill recently presented to Parliament is destined to avert as a prodigious national loss, especially if it can be made compulsory.

The lessons we have learnt during the war show that mothers must receive practical instruction in the care of young children, as also in the making of their clothes, in preparing food and drink for the sick, and in domestic cleanliness and home nursing. Mothers should receive, by State control, proper, prompt and skilled attendance before, during, and after confinement; infants should receive treatment until the child goes on to the school register, and the home should be visited by authorised persons so as to foster a public opinion educated to set a high value upon infant life, and not to tolerate its neglect. The rebuilding of our manhood is only possible when the dignity of motherhood has become the corner-stone of our public faith and creed.

The war has immensely stimulated people into a common purpose about children, and nothing has done more to concentrate national attention upon the ignorance, carelessness, and neglect in connection with child life, and the

permanent damage to mother and children that is still going on than the realisation of the enormous sacrifice of our adult manhood in this war. Not only is the Government, but also many local authorities are now awakening to the great interests involved in saving children by the help of health visitors, and by the establishment of infant welfare and maternity centres, crèches, day nurseries and schools for mothers, which the new Bill and the Education Bill propose. Nor is this solicitude confined to public bodies, because large employers of labour for whom women work in great numbers (*e.g.* Anderson Scott and Sons, of Carlisle, and others), have made arrangements for special rooms with plenty of light and sunshine to be used in their works as nurseries with qualified women in charge. So much are these facilities appreciated by the mothers, that they willingly pay small sums—from 5*d.* for one child to 8*d.* for two—to cover the cost of the food supplied to their children, whom they are able to visit at intervals during their working hours. There have been more infant welfare centres and day nurseries started since the war than during the previous ten years, and although there had often been health weeks before the war, there had never previously been a Baby Week, and fortunately welfare work has never been the bone of contention of party politics. In July, 1914, there were 400 infant welfare centres at work, but happily since the war these have increased rapidly, and now there are 1,200 at work, and their numbers are still increasing, and it is satisfactory to learn that although 5,000 of these are necessary to compete adequately with the work, the growth of these centres is both rapid and regular. There are to-day no less than ninety national or central societies at work, doing practical organisation and effecting propaganda about the treatment of babies, and there is a growing need for the co-ordination of educational societies rather than for their further competition in practical action; and we hope this concentration of efforts may come when the Minister of Health has been appointed. Although, so far, we have made few sacrifices compared to those made by the soldiers at the front, we have made some progress in matters pertaining to health, but unless some scheme of reconstruction is actually commenced during the war—and the Notification of Births (Extension) Act, 1915, affords a most helpful basis—there is a fear that the incubus of lethargy and indifference may again re-assert itself.

The National Association for the Prevention of Infant Mortality and the National Society of Day Nurseries, have worked hard in order to keep the children of working mothers properly fed, clean and looked after whilst they themselves were at work. The National Union of Women Workers has long since advocated the establishment of nursery schools with small clinics attached where the mothers, when present, may be taught to sew and to cook, and where the babies may benefit through medical consultations, especially in case of wasting or malnutrition, and the National Union has initiated a number of these baby hostels in different centres; a feature of some of these being the supply of milk for the infants to supplement breast-feeding, or where this is impossible. Some town councils have most creditably helped in this matter, and a great deal of useful work is done by training so-called "home helps" to look after the babies, but voluntary effort cannot be relied upon to yield either the necessary financial support or to carry out the work without proper remuneration. The work of these societies is arduous and continuous, for they endeavour to restore the deficiencies consequent upon a faulty home life, and re-education is needed which takes time and trouble. Many local authorities have already appointed tuberculosis officers—as they are called—to examine and advise in regard to children who have been damaged or maimed by tubercle, and it is not realised how destructive this is to child life. From 1914 to 1916 inclusive, 71,007 cases of non-pulmonary tuberculosis were notified, of which no less than 25,451 died under the age of fifteen years. These figures show how prevalent tuberculosis is in young people, and yet it is a condition which is eminently remediable in the early stages. If places may be named, Huddersfield in particular has taken the matter of child life into its serious consideration, for 97 per cent. of the total births in this city are visited by medical officers immediately upon the receipt of notification of birth. York is also showing much activity in this direction, and Leeds in 1916 established by voluntary effort a home for the children of soldiers and sailors during active service, which has now passed under municipal control, for the Sanitary Committee of the City Council has taken over the work, which is now undertaken by a joint Infant Welfare Committee from nine centres, and composed of members of the Sanitary Committee and the Leeds Babies Welcome Association, with the result that the relief afforded is worked as a hospital under the

direction of the Medical Officer of Health and his assistant, in conjunction with six trained nurses and eight probationers, and this hospital gives advice as well as treatment for the three great disabling illnesses in children, viz., rickets, marasmus, and tuberculosis. Bournemouth also has its Health and Mothers' Aid Association.

In regard to ante-natal care, which means the control of causes contributing to many of the child fatalities that occur during confinement—and during the nine months of ante-natal existence it is computed that 100,000 infants are miscarried annually, or are prematurely or dead-born—the Midwives' Institute, among others, has issued special instructions to midwives, urging them to aim at saving life by keeping the pregnant woman in good health, bodily and mentally, so as to anticipate any complications at this period by securing appropriate treatment in time, and thus preserve pregnancy to full term. The midwives are well able to advise as to the toxæmias of pregnancy, the havoc of venereal diseases, the adequacy of pelvic measurements, and some of the dangers to be avoided by being able to test and examine the urine. They are particularly advised to visit the home "by consent," and give help as to the personal care and arrangements desirable in the interests of the mother and infant. It has been suggested by some, and already an effort has been made, to standardise the qualifications for welfare workers, because it is found that women of widely different attainments hold similar posts, some of them having only a comparatively short experience, whilst others had given years of arduous service in a hospital or an infirmary, and had in consequence developed fully their capacity for responsibility. The need for such a standard for Women Sanitary Inspectors has already been brought to the notice of the Local Government Board, which has recognised certificates for Health Visitors granted by various training centres, the duty of these visitors being to keep children that are over a year old under supervision, so as to prevent rickets and the special respiratory diseases to which they are so liable. The great Association of Infant Welfare and Maternity Centre is endeavouring to extend its affiliated branches, and it has started an Employment Information Bureau, but there is a pressing need for superintendents of maternity and child welfare centres, because so many mothers are ignorant of what is now very significantly called "mothercraft," and they are too apt to give up breast-feeding for some advertised fashionable food which perpetuates a lack of vigour and a lessened resistance to disease in the child. The work now being done by the National Association for the Prevention of Infant Mortality, by the Women Sanitary Inspectors and Health Visitors Association, by the Local Government Officers Association (which, as far back as 1905, formed a central organisation with local guilds), and also by the National Union of Women Workers of Great Britain and Ireland, with its 2,000 women enrolled in the Patrol Committee: all these show the need there is for workers in relation to health and the still greater need there is for co-ordinating organisation by a Minister of Health, who would already have at his service not only the efficient help of the Local Government Board, but also the most valuable help of the National Insurance Commission, through its Medical Research Committee. In America there has been great progress in the direction of supervising officially the various social conditions which affect child life; an official has been appointed who is described as the Chief of the Children's Bureau, and he is attached to the U.S. Department of Labour. His duties are to collect such facts as the influence of the density of the population upon child life, to report upon the types of recreation facilities which should be available in any one city, and to give information as to school buildings, playgrounds, open spaces and play retreats for small children, so as to prevent street play and loitering, which are forbidden by law. The work of Sir Arthur Newsholme, Mrs. Humphry Ward, and others, has well prepared the way for special action upon this aspect to be taken in this country.

Whilst upon the subject of child-life, the war has taught us to reconstruct our attitude towards "illegitimacy." In a recent address Sir Bernard Mallet has shown that, in spite of unfounded alarm and rumours, there is a practical constancy in the number of children—about 50,000—who are born out of wedlock annually in the United Kingdom, of which over 36,000 are in England and Wales. There is a much heavier death-rate among this class of children than among the ordinary; the infant mortality is two or three times greater in those born out of wedlock than is the case in the legitimate offspring, and this fact is true both in this country and in the Colonies. In the Borough of Hampstead, which has many social advantages, the child mortality, in or out of wedlock, is as 197 to 60, and in New South Wales it is 162 to 67, and the reasons for this are want

and necessity. If there is no parental responsibility and no protection, the lot of the necessitous mother is hard, and this is the chief cause of the high mortality among the illegitimate; for if, as in Norway since 1914, the State assumes the father's responsibility, or finds him and fixes the care of the child upon him, the death-rate among illegitimate children falls to the normal rate. This fact shows incontrovertibly that infant mortality is tried by and governed by poverty, want, and anxiety. Remove these and the children live. There are not a few persons who feel that any relaxation of deterrent measures may become a moral danger, but the question must be viewed primarily from the public health standpoint, and the interest of the child should be considered paramount. Upon this reasoning there should be no differential treatment shown towards any necessitous mother, and public feeling since the war tends strongly to this view, and it is advocated that there should be special waiting homes for expectant mothers, and also some place where mothers could remain with their children for a time, or at any rate during the period of nursing, and that they should be provided with a suitable allowance to enable them to help to pay for the use of special day nurseries. There may rightly be differences of opinion as to these homes being rate-aided or self-supporting, but a strong feeling exists that the assistance to unmarried mothers should not be through the Poor Law. It is certain, however, that the law must be altered so as to enable adoption to be safeguarded and legitimation of the child to be secured by the subsequent marriage of the father and mother, and possibly in other directions which will be indicated when referring to the lessons of the war upon the law. It is permissible to infer that in regard to child-life, the war has "created an atmosphere" in regard to the falling birth-rate, also in regard to infant as well as to maternal mortality, and to the damage to both, which can be avoided; that the work of the midwife, the health visitor, the district and school nurse must be better known and more fully appreciated, and that local authorities must obtain further increased power, by the legal sanction proposed, in order to support maternity centres, infant welfare organisations, and hospitals in particular, so that the different local authorities may be enabled to deal with these two very important factors of mother and child. All of us are aware that the Local Education Authorities and the Local Government Board have already used their present powers to supply grants in aid of maintaining the work of accredited institutions, but this needs extension and co-ordination, and although I cordially appreciate the work of voluntary committees, there is far too much of this left to the humanity and generosity of the public, and we must remember that the voluntary work of one generation becomes the accepted duty of the State in the next, and this is one of the lessons of the war.

Another of the great lessons of the war derived from the increase of juvenile crime has been to direct greater attention to attracting the children by amusements so as to provide them with diversions from the streets, and to promote the welfare of boys and girls by offering them useful counter-attractions to loafing and the temptations to be idle. It is necessary that all educational authorities should be in touch with what is being done voluntarily in this way by each authority in its own district, and the first Education Bill proposed a special standing committee, called the Juvenile Organisations Committee, for the purpose of supporting the work carried on by voluntary organisation amongst boys and girls who have left school. Lord Desborough pointed out the value of this in a strong appeal for a closer connection between all the societies working in the interests of the juvenile adult, viz., those between the ages of fourteen and eighteen; and I venture to suggest a further link which might be of the utmost help and value, that all school children during their last year of school life should be brought into touch with the voluntary clubs in their district. The fact that representatives of the Federation of London Working Boys' Clubs were to be on the Juvenile Organisations Committee was a great hope for London, as the children of to-day will be the rulers thirty years' hence, and the good and wholesome influences of these clubs will prove to be an inestimable asset to the country when the boys grow into men.

MEDICAL.

In the department of medicine we have received far-reaching lessons, and the chief is the value to surgery and medicine of the ancillary departments of bacteriology and microscopy. These are in future destined to be the indispensable assistants of the physician and surgeon, and their interpretation of the condition of wounds has been invaluable, as no surgeon will in future operate upon deep and broad areas of wounded surfaces unless he has the assurance of the bacteriologist and microscopist that the procedure is free from risks. Probably there

are at least five principal lessons derived from the war in regard to surgical practice which are bound to afford considerable benefits and advantages in the future to the civil population. One of these, which had been adumbrated before the war, is the success attending the transplantation of bone, or the surgical method described as bone-grafting for serious injuries and diseases, and experience has shown the value in this regard of "fixing" all bone injuries. Closely related to this is the importance, and even the necessity now agreed upon by all the great surgeons, of retaining —except in "stumps"—all loose pieces of bone or "sequestra" in comminuted fractures—*i.e.* so long as these pieces of bone have the slightest tag of periosteum attached to them, and sometimes even when they are free. A third lesson derived from the war has been the great success attending the so-called excision of wounds. All gunshot wounds may correctly be described as septic; hence the great discovery of the value of excision of wounds, and there have been few wounds throughout the war which could have been treated upon aseptic lines, and, in consequence, the method has been antiseptic rather than aseptic. As a corollary from this has been the supreme value of intermittent application of an antiseptic in the form of hypochlorite of sodium, in order to cleanse wounds and to destroy bacterial infection. This treatment of wounds by periodic irrigation or suffusion has been a great discovery, and is attributed to the genius of two men whose names it bears—viz., the Carrel-Dakin treatment of wounds. It enables extensive septic surfaces to be cleansed and to be subsequently drawn together by primary or secondary suturing, when union and healing take place directly. Although this surgical treatment has been one of the most important discoveries, it is only right to state that there are some surgeons of eminence who consider that it has risks of its own, one of these being secondary hæmorrhage, the bane of surgery in the remote past. Fourthly may be mentioned the advance in the surgery of the pleural cavity, and in the direct surgical treatment of hæmorrhage into the lungs which may open a new method of dealing with tuberculosis; and lastly, upon which I propose to dwell, there is the great lesson derived from the care and treatment of our brave men who have broken down in nerve and mind through the overwhelming stress and strain of action against the incessant terrors of high explosives. The treatment of these cases is one of the most difficult as it is the most responsible in medical art, for, to succeed, it requires special qualities of heart and head that are not pre-requisites in the other departments of medical practice. As is well known, most cases of "shell-shock" carry no wounds; they are rarely to be found in the front trenches, and they most frequently occur at the base or, it may be, whilst on leave. It is true that some have suffered from direct and definite physical injury to the nervous tissues, owing to the concussion or percussion of high explosives, which suddenly burst with a pressure, positive or negative, varying from 100 lb. to the square inch. As we know from the results of aircraft bombs, doors and windows may be blown in or they may be drawn outwards; but the majority of shell-shock cases are those who have suffered from the emotional strain of long-continued thinking and worrying over the anxiety of trench fighting with its horrors, harassing uncertainties and appalling sights—the element of "fear," in one or other of its many forms, reacting upon a predisposed temperament, and this is the predominant factor in the emotional disturbance.

I maintain that in every case of shell-shock there are definite mental as well as nervous symptoms, and although this question is both debatable and debated every shell-shock case is a mental case, and he deserves the best treatment his grateful country can give him. Every mental case in this war has been treated in the first instance without the legal sanction of the committing medical certificate, and in the scheme of reconstruction legal power must be obtained to apply the same treatment to the civil population.

For several years before the war there had been a great and deeply felt agitation, in which many of us joined, to ensure that all mental cases in their earlier stages, those that might be described as functional mental disturbances, should be treated at first without commitment into an asylum, because, upon recovery, which in favourable cases occurred within a few weeks, the painful memory of the illness associated with the disabilities inevitable from certification caused these persons to be shunned and avoided in the future. They were hence regarded as not only outside the pale of sympathy, but persons who could not even after recovery be trusted in any responsible position. Upon leaving the asylum they found themselves in a world of their own without friends, without help, and without work. The consequence of having been certified and detained as a lunatic for however short a period meant for them the deprivation

of civil, financial, political, and domestic rights, and there remained an undeserved social stigma, which not only marred their lives, but which also blighted the prospects of members of their family; and those dependent upon them suffered, and were not infrequently drawn down to a lower plane of social life, from which they discovered that an emergence was almost impossible. The subject was for some time looked upon as one demanding immediate legislation, and it was strongly felt that the most pitiable and the most helpless of our fellow-subjects should not be confined and deprived of their liberty without an effort being made to try all other measures first. As a matter of fact, in the treatment of mental diseases, legislation interferes to-day with the legitimate work of the true physician. For these reasons, therefore, several Bills were brought before the Legislature with the view of bringing about a much-needed change; some of these Bills had for their object the establishment of special homes or receiving hospitals for mental patients in their earlier stages; one Bill, such as that introduced into the House of Lords in 1914, aimed at extending to these and similar cases the necessary medical treatment during a period of six months in some approved home; whilst a third Bill introduced into the House of Commons—the Mental Treatment Bill—aimed at treating for a limited period without certification all cases of mental breakdown in consequence of the war, and therefore without the usual commitment into the asylum. Public feeling had thus been gradually prepared, by a criticism of the past, for the wise and considerate treatment arranged for these cases, and so far as the Army was concerned, this was carried out by the courage and the ability of the late Director-General, Sir Alfred Keogh.

As was naturally to be expected, mental and nervous breakdown were inseparable illnesses from an active and strenuous life under conditions of stress and fatigue associated with irregularity of food and sleep and with great and unaccustomed hardships; so that, shortly after the commencement of hostilities, cases of mental and nervous breakdown began to occur and some reached England as early as September 1914. This was the time to act, the fashion of the period had changed and insanity immediately became a matter of national importance. Public opinion had been roused, and a special officer (Col. Aldren Turner, C.B.) was appointed to advise upon their treatment. The first important step was to realise the nature of the cases in order to discover what treatment should be necessary, and what accommodation would prove suitable for them, also what suggestions might possibly be made for the future. It was found that the cases coming home from overseas could be divided roughly into three groups: firstly, those with definite material damage to the nervous system, which might be received either into the ordinary hospitals or into auxiliary hospitals, or even into the central military hospitals without special sections for the treatment of nervous conditions; secondly, those coming under the common term "neurasthenia"—emotional or commotional shell-shock—cases which should be treated either under experts in neurological departments attached to the military hospitals or in special hospitals previously established for the treatment of nervous disorders; and thirdly, there was the group of cases suffering from more definite and well marked mental symptoms, who required special treatment, and preferably in institutions previously adapted for mental diseases and ministering to this particular class before the war, and throughout this new departure the help of the Board of Control has been invaluable to the Government and to the country for their readiness in every way to offer and to expedite the emptying of so many large public asylums of their former civil population so that they might be used for the reception of the military.

In the march of science and in the progress of medical treatment no finality can be applied to such a complicated subject as the care and treatment of mental diseases, but for all three groups named a period of rest in an atmosphere of persuasive recovery was necessary, in order to compose the nervous system of these overwrought soldiers, and this has now been provided for each Army area in France. The mystery attaching to insanity was relinquished, it was properly regarded as a bodily disorder, and a hospital atmosphere under those possessing special knowledge was created.

The cases were treated in specially arranged nervous or "shock hospitals," situated near the clearing hospitals, where they remained until sent to the local convalescent camps, where the treatment was modified to suit individual cases, or where it was continued further until the men rejoined their units. If they did not progress, and the response to treatment was not satisfactory, they were then sent to the base hospitals, whence they were drafted home for further care. As a base in England, accommodation was provided for these cases at Netley, where both a neurological

and a mental department were established and later on, as the cases became more numerous, Netley was used as a clearing hospital, the "nervous" cases being drafted to the 4th London Territorial Hospital, to the Red Cross Hospital at Maghull, and to the Springfield War Hospital; whilst the mental cases, which have already numbered over 9,000, were sent to the Napsbury War Hospital, St. Albans, where over 2,000 mental cases have been treated, and to the Lord Derby War Hospital, Winwick, where up to date over 3,000 mental cases have been received. If the patients belonged to Scotland, then the "nervous" cases were drafted to the Royal Victoria Hospital, Edinburgh, and the mental cases to the War Hospital near Perth, and to that at Dykebar, near Paisley, which has received to date over 2,000 mental cases; and if to Ireland (where already about 1,500 cases have been received), then they were sent to the Richmond Hospital with thirty-two beds, or to the King George Hospital, Dublin (but this does not keep the mental cases), or to the War Hospital, Belfast, with 400 to 500 beds, a few beds being retained for officers. There were in addition various auxiliary and central military hospitals, as well as special hospitals for officers, such as that at Palace Green with its dependencies in London, and that at Craig Lockhart in Scotland, and for men in Ireland the Red Cross Hospital, Hermitage, Lucan, Co. Dublin. There have been very considerable extensions since then to meet the great demand, the number of the mental and combined nervous cases probably not being much under fifteen thousand; but these need not be referred to further here. One additional feature in regard to the present treatment of our mental soldiers needs to be mentioned, and that is the establishment under the Ministry of Pensions of after-care homes for the discharged soldier who has not recovered, and whose condition renders him unfit for further service. The discharged soldier or the "ex-Service man," as he is described, is encouraged to enter a home of recovery or a village settlement, in which he may be further "annealed," and where he is taught some suitable occupation according to his taste and capacity, being thus prepared for a fresh start in civil life. This after-care treatment is a bridge between the hospital and social life, and a great public effort is now being made to provide this school-life in a hospital atmosphere so that the soldier may fill a remunerative gap in what seems in the future to be the very difficult problem of opening up the "serried ranks." It is computed that considerably over 300,000 men have already been discharged from the Army, of whom probably a fifth are those who have been rendered unfit for their previous occupations through various disabling illnesses of the mind and the nervous system, and if such means of restoration are found to be useful, and helpful and beneficial for the military, the lesson is a great and necessary one for the civil population, and legal changes must be obtained to facilitate this treatment without delay.

[The concluding portion of the paper, with the discussion, will be published next week.]

ENGINEERING NOTES.

Electric v. *Steam Haulage in Relieving Coal Shortage.*—The *Railway Review* says that while the question of coal shortage in the United States of America has been brought so prominently to the attention of the public by the recent closing order of the Fuel Administrator, it is interesting to note the splendid work that is being done, and the savings effected by the railroads that have adopted electricity as a motive power on a part of their lines. On the Elkhorn grade electrification of the Norfolk and Western Railway, which is one of the biggest coal-carrying roads in the country, the 270 ton Baldwin-Westinghouse electric locomotives haul a 3,250-ton train of steel cars loaded with coal, en route for eastern points. Previously to the electrification it required three of the biggest modern type of Mallet locomotives equipped with mechanical stokers to haul a train of this tonnage up the Elkhorn grade at a speed of seven miles an hour. Two electric locomotives haul it up the same grade at fourteen miles per hour, double the speed formerly obtained by the steam locomotives. With electric propulsion, the same coal traffic can, therefore, be hauled with about one-third the former number of locomotives and half the number of engine and train crews. Of equal interest is the statement recently made by the Commission of Agriculture of the State of Montana in regard to the use of electric power by the Chicago, Milwaukee, and St. Paul Railway, now obtaining 160,000 kw. of electric power from the hydraulic plant of the Montana Power Co., and the saving in fuel effected by this use of water-power instead of coal has been very gratifying to the State officials. The Commissioner states: "To give an idea of the value of the power which is being generated by these plants, it may be stated that to produce 160,000 kw. from coal would require the yearly consumption of 2,500,000 tons, which, at the average price of $4 which would apply at the points where the power is used, would amount to $10,000,000. When it is considered that the value of this coal is, by means of water-power, being saved each year, and that during the next ten years this saving will, in all probability, be increased seven or eight times, it is not difficult to understand that true conservation consists in encouraging the rapid development of water-power." It has been estimated that the

shortage of coal last year amounted to 50,000,000 tons; the saving, therefore, by this one company alone of 2,500,000 tons of Montana coal amounts to 5 per cent. of the total shortage in the country last year.

Power from a Volcano in Italy.—Over a year ago (December 15th, 1916) a note was given in this column on this subject. According to *Chambers's Journal*, extensions are being added to the generating plant which will increase the output to 55,000 h.p. while a project is on foot for utilising the sources of volcanic heat near Naples, where high temperatures are all met with at a comparatively shallow depth below the surface. These schemes, however, depend upon natural conditions, and it has occurred to an American engineer, Mr. N. B. Wales, that similar conditions could be produced artificially. According to Mr. Wales's plan, two or three tubes should be sunk in the ground where heat is likely to be met with comparatively near the surface, until a temperature of 350° to 450° F. is reached. These tubes are of different sizes, and are arranged one inside the other, leaving space enough for steam to come up between them. Water is to be pumped down the central tube and into the heated crater at the bottom, where it would be turned into steam, and rise up through the space between the inner and the outer tubes to be utilised for generating purposes at the surface. Many areas are said to exist in the United States where the necessary temperature is to be met with at depths of under 5,000 ft.

British Oil.—In a paper recently read before the Institution of Petroleum Technologists, Mr. E. H. C. Craig said that a very large quantity of mineral oil could be produced in this country, and much material now neglected or treated as waste could be utilised for the purpose. There were several minerals from which oil could be obtained in this country, namely, oil shale, coal, cannel coal, blackband ironstone, lignite, and peat, but of these the only one at present utilised was oil shale, and that only in Scotland. This industry produced 320,000 tons of oil per annum, but not more than 60 per cent. was fuel, and the percentage of petrol was negligible. Of the other oil-yielding materials cannel coal was the most practicable, and though large quantities of it were being brought to bank at collieries in this country, it was thrown on the waste heap as useless, while a still greater quantity was never brought to the surface. Of blackband ironstone, there still remained a number of seams that could be utilised. Many seams, also containing both coal, ironstone, and cannel, existed which were not worked because the coal was too thin, but would, if mined for oil purposes, add to the coal and iron supply as well. The cannels in this country would give an average yield of 35 gallons per ton, as compared with 22 gallons, the yield of the Scottish shale companies, which, however, were paying high dividends. The new industry must be started on broad lines and on a large scale, and at least six retorting and refining works could be established without any difficulty.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 27...Surveyors' Institution, Great George-street, S.W., 5 p.m. Annual General Meeting.

Geographical Society, Burlington-gardens, W., 5.30 p.m. Anniversary Meeting and President's Address.

TUESDAY, MAY 28...London Society, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Mr. H. W. Fincham, "The Knights of St. John of Jerusalem (Hospitallers) and their London Home."

Royal Institution, Albemarle-street, W., 3 p.m. Sir H. Newbolt, "The Poetry of Thomas Hardy. Lecture I.—'The Dynasts.'"

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. W. Burford, "The Application of Electric Power to Oilfield Requirements."

Zoological Society, Regent's-park, N.W., 5 30 p.m. 1. Mr. N. Taylor, "A Case of Hermaphroditism in a Lizard, *Lacerta viridis*." 2. Mr. C. T. Regan, "Freshwater Fish as Food."

Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. 1. Dr. W. E. Adeney and Mr. H. G. Becker, "The Rate of Solution of Atmospheric Nitrogen and Oxygen by Water. Part I.—The Rate of Solution by thin Films of Water." 2. Dr. G. H. Pethybridge and Mr. H. A. Lafferty, "A Disease of Flax Seedlings caused by a Species of Colletotrichum and transmitted by Infected Seed." 3. Dr. F. E. Hackett, "The Twist and Magnetisation of a Steel Tube in a Spiral Magnetic Field."

WEDNESDAY, MAY 29... ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. Dr. M. O. Forster, "Organic Chemistry in relation to Industry."

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor S. Delépine, "The Conservation of Milk."

THURSDAY, MAY 30...Electrical Engineers, Institution of, Albemarle-street, W., 6 p.m. Annual General Meeting.

Royal Institution, Albemarle-street, W., 3 p.m. Lieut.-Colonel Sir F. Younghusband, "The Abode of Snow: its Appearance, Inhabitants, and History." (Lecture II.)

China Society, School of Oriental Studies, Finsbury-circus, E.C., 3.30 p.m. Dr. E. D. Ross, "High Tartary."

FRIDAY, MAY 31...London Chamber of Commerce, 97, Cannon-street, E.C. Mr. R. B. Kent, "A Common Commercial Language."

Royal Institution, Albemarle-street, W., 5.30 p.m. Mr. L. Binyon, "Poetry and Modern Life."

SATURDAY, JUNE 1...Royal Institution, Albemarle-street, W., 3 p.m. Professor C. J. Patten, "Problems in Bird Migration." (Lecture II.)

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REGISTERED AS A NEWSPAPER.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 3...Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Rev. C. Lias, "Germanism."

Farmers' Club, at the Surveyors' Institution, 12, Great George-street, S.W., 4 p.m. Sir Mark Collet, "Rural Housing."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 7.30 p.m. 1. Dr. H. J. S. Sand, "A Cadmium-vapour Arc Lamp." 2. Mr. A. R. Powell, "The Estimation of Tin in high-grade Wolfram ores and the use of Lead as a reducing agent in Pearce's assay."

Geographical Society, Kensington-gore, W., 5 p.m.

TUESDAY, JUNE 4...Gas Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 10.30 a.m. (Annual General Meeting.) Presidential Address by Lord Moulton.

Royal Institution, Albemarle-street, W., 3 p.m. Sir H. Newbolt, "The Poetry of Thomas Hardy. Lecture II.—The Shorter Poems."

Alpine Club, 23, Savile-row, W., 8.30 p.m.

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. A. E. Bullock, "Interiors of Famous Mansions."

WEDNESDAY, JUNE 5...British Academy, at the Royal Society, Burlington House, W., 5 p.m. Mr. L. Binyon, "English Poetry in its relation to Pictorial and other Arts."

Geological Society, Burlington House, W., 5.30 p.m.

Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Major M. W. Flack, "The Health Aspects of Aeronautics."

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 5 p.m. 1. Mr. E. G. Jones, "A Method for the Colorimetric Estimation of Cobalt." 2. Mr. A. C. Chapman, "Nucleic Acid and its Analytical Examination." 3. Mr. J. N. Rakshit, (*a*) "Opium Wax"; (*b*) "Estimation of Morphine in Opium by Polarimeter." 4. Mr. P. J. Fryer, "The Application of the Valenta Turbidity Test to Mineral Oils." 5. Mr. J. H. Johnston and Dr. A. W. Stewart, "The Valenta and Crismer Tests." 6. Mr. A. W. Blyth, "A New Method of Identifying Starches." 7. Mr. A. L. Bacharach, "Two Plant Products from Colombia, S.A."

Literature, Royal Society of, 2, Bloomsbury-square, W.C., 5 p.m. Lecture by Professor M. A. Gerothwohl.

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Dr. P. Nelson, (*a*) "The Earliest Type of English Alabaster Table"; (*b*) "Some Unpublished English Alabaster Carvings."

Gas Engineers, Institution of, at the Institution of Civil Engineers, Great George-street, S.W., 10.30 a.m. (Annual General Meeting continued.) "Report of the Refractory Materials Research Committee" and other business.

THURSDAY, JUNE 6...Linnean Society, Burlington House, W., 5 p.m. 1. Mr. C. C. Lacaita, "A Revision of some Critical Species of *Echium* [Viper's Bugloss], with a description of *Echium judacium*." 2. Captain A. W. Hill, "Experiments with *Cyclamen*." 3. Messrs. R. Paulson and S. Hastings, "On the Relationship between the Symbionts in a Lichen." 4. Mr. W. C. Worsdell, "Abnormal Apple-blossoms and Fruit."

Chemical Society, Burlington House, W., 8 p.m. Dr. H. T. Brown, "The Principles of Diffusion: their Analogies and Applications."

Royal Institution, Albemarle-street, W., 3 p.m. Colonel Sir F. Younghusband, "The Abode of Snow: its Appearance, Inhabitants, and History." (Lecture III.)

FRIDAY, JUNE 7...Royal Institution, Albemarle-street, W., 5.30 p.m. Sir Boverton Redwood, "The Romance of Petroleum."

Astronomical Society, Burlington House, 5 p.m.

SATURDAY, JUNE 8...Royal Institution, Albemarle-street, W., 3 p.m. Professor C. J. Patten, "Problems in Bird Migration." (Lecture III.)

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

TWENTY-SECOND ORDINARY MEETING.

Wednesday afternoon, May 29th; SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., in the chair. A paper on "Organic Chemistry in Relation to Industry" was read by DR. MARTIN O. FORSTER, F.R.S., Treasurer of the Chemical Society, and a Director of British Dyes, Ltd.

The paper and discussion will be published in a subsequent number of the *Journal*.

EXAMINATIONS.

The results of the Advanced and Intermediate Examinations (Stages III. and II.), held from March 18th to the 26th, were sent to the centres concerned on the 23rd inst. It is hoped to send out the results of the Elementary Stage early in June. The time-tables for the 1919 examinations will shortly be sent to all centres. The first examination will commence on Monday, April 7th, and finish on Monday, April 14th. The second will commence on Monday, May 26th, and finish on Wednesday, June 4th.

PROCEEDINGS OF THE SOCIETY.

EIGHTEENTH ORDINARY MEETING.

THE MENTAL EFFECTS OF THE WAR AND THEIR LESSONS IN REGARD TO MEDICAL AND SOCIAL RECONSTRUCTION.

By MAJOR SIR ROBERT ARMSTRONG-JONES, M.D., R.A.M.C.

(*Continued from p.* 443.)

It is urgent and necessary that the disability which occurs through a mental illness should be promptly dealt with, and it is one of the objects of this paper to hasten this movement as one of the most pressing and imperative claims in the great scheme of reconstruction, and I desire to emphasise this point with all the earnestness and force that a special experience of forty years can command. It is not because there are any violations of personal liberty possible under the present lunacy system that this movement is pressed, for I do not think this is the case, but it is because the poor have no opportunities, such as are already permitted to the rich, to obtain voluntary treatment for a mental illness that a demand for a change in the law is made, and every doctor knows that certification has the effect of retarding treatment. There is no allegation made to-day at all that patients suffering from a mental illness are detained longer than is necessary, nor that the patient is deprived of his liberty for corrupt motives, and it is believed that the licensed houses of to-day, both large and small, supply a real social want. There are many families who prefer the privacy and comfort of a small home to treatment in a large institution with a mixed population; in addition to which there is the natural desire, where a stigma may be reflected upon the relatives in consequence of the certification and commitment, that secrecy should be preserved and exposure avoided, which are believed to be easier in a small establishment than in a large one not limited to the immediate domestic life of a few persons.

Statistics have frequently been presented in regard to the rapid recovery of mental cases during the earlier stages of this illness. Col. Toogood, R.A.M.C., has referred to the recovery rate in 23,000 cases during the first thirty-one days of treatment; Col. Nathan Raw, C.M.G., R.A.M.C., has presented publicly the statistics relating to over 6,000 cases; and Dr. James Carswell, now one of the Deputy Lunacy Commissioners for Scotland, has related his own experience of over 1,000 fresh cases annually, with the result that from 42 to 56 per cent.

of all cases coming under their care, and that of others, recover and are discharged within four weeks of the commencement of treatment. We know, further, that of all the cases which recover in the London County Council Asylums, 65 per cent. leave the asylums within the first twelve months of their admission.

Many patients are extremely susceptible to the suspicion of detention, and are most sensitive to any notion of restraint or confinement: indeed such a feeling prevents their appealing for help and advice. To a morbidly sensitive individual, the idea of the deprivation of personal freedom retards treatment, whereas if assured that he could receive voluntary treatment based upon voluntary residence, viz., the treatment which approximates the hospital treatment for bodily ailments, it would be widely appreciated, there would be no resentment, and recoveries would be expedited. During the last year of which we have a record—*i.e.* the Report of 1916 by the Board of Control—over 18,000 persons in England and Wales were certified as suffering from their first attack of mental breakdown and admitted into asylums, with the consequent limitation of usefulness to themselves and their families through the stigma attaching to commitment. If legal sanction were given, with proper safeguards against designing persons making a profit out of affliction and illness, and if the care of mental illness were properly guaranteed—which the State has done in the case of venereal diseases by prohibiting treatment by quacks, advertisers, and other improper persons—and if the State would help to pay for treatment in ordinary hospitals, there would come forward a body of qualified men and trained women eager to give their services in the work of helping to right the most delicate disturbance of that very complicated human mechanism—viz., the organ of the mind. Every doctor knows that before his patient is certified, all the friends beg him to try other means before asylum commitment, which registers the insanity and perpetuates the stigma. It is felt that the work of mental healing must begin long before the certificate becomes necessary, and although this may not be the place to discuss the details, opportunities must be given to the mental patient to be treated early. There should be no taint of pauperism in the relief of any unavoidable illness, particularly an illness so entirely disabling and so appealing as is a mental illness, and the Local Government Board, or some other Department, should supplement—preferably not from the Poor Law—the maintenance of mentally ailing indigent persons in the ordinary general hospitals or in some suitable homes of rest. If the certificate becomes necessary (and the need for asylums such as those which now exist will always be justifiable for the detention of dangerous patients), it should as now be authorised after the justice had seen the patient, but the patient must not be brought before the justice as is sometimes done at present, with the result that the patient feels himself to be a suspected criminal and not a sick person, which greatly retards his recovery. We need legal power to treat mental patients like other patients, but preferably, and in order to avoid abuse, for a definite and fixed period. Power must also be granted to poor persons to enter the county asylums and the other public mental hospitals voluntarily, but to be only detained during the early phases of the illness and with their own assent. It is an anomaly to insist upon an aggression on personal liberty before a patient can receive adequate and proper treatment for a mental illness, whilst his own assent is now readily accepted for his treatment for a bodily disease. A mental disease if not cured is of far greater moment to the sufferer, as well as more serious to his family and dependants, than is a bodily disease, and yet he has to wait until his disease is confirmed before he can receive remedial assistance. The success which has been obtained during the war in the care of mental patients without any certification is surely sufficient justification for its limited extension in peace time; at any rate, it is one of the strongest and deepest lessons of this great war.

Lastly, I have met many young men, as helpers in operating theatres, X-ray and electrical departments, and in bacteriological laboratories, who before the war were engaged in business and commerce. In their new work they have suddenly discovered ideal and congenial vocations, and I should personally like to see all the medical schools throughout the country offering "free places" to these young men after the war, with the object of affording them an opportunity of helping to fill up the depleted ranks of the medical profession. I consider that every military hospital should possess workshop schools open to soldiers during their convalescence and to prepare them for future employment, but "Labour" so far has not permitted such instruction to be given.

Labour.

The submarine and the aeroplane have been the surprises of the war, and they have probably

brought along with them great changes in the conditions of trade as well as altering the whole economic conditions of the British Isles, and it is incumbent upon this country not only to use every effort after the war to extend our home industries but to commence now. There are already signs that labour is being organised upon a national rather than upon a class basis, and this will prove to be the best corrective for the deep-rooted misunderstanding between Capital and Labour and between employer and employed, which started as far back as the beginning of the industrial revolution one hundred years ago.

In order to rebuild the nation's fortune, or indeed to live at all and to pay for the war, the great object is to put out the maximum capacity of our people; in other words, there must be a greater output of work, which means that we must have more machinery and also import more raw material, for which we must have ships. This will produce more goods for export, but increased production depends also upon good feeling and friendly relations between employer and employed. It is no exaggeration to say that some of the trade unions have compelled the limitation of work so as to restrict the output. Of this I have personal knowledge. Neither is it any exaggeration to state that employers have also in the past kept down the rate of wages because the workmen earned too much. If the country is to be reconstructed upon progressive lines, and if we are to profit from the lessons of the war, we must recognise there are no royal roads to reconstruction; but certain general considerations hold good in all human affairs, and one of these is good feeling and goodwill. "Equality is the great human formula of the coming revolutionary era," and there must be a realisation that socialistic theories are fatal to us, for they only tend to keep the agitators occupied, and as long as industrial difficulties last, so long will the position and the livelihood of socialist *doctrinaires* be maintained, for they live and thrive only upon suspicion and strife between master and workman, and their object is to stir it up. It is certain that more can be done by voluntary organisation than by State control, as we have seen in shipping construction, and at present there is a strong feeling on the part, both of employer and employed, to keep off as much State interference as possible, and the sure method of progress is to foster a good feeling, for the average workman has no ill-will against his employer, and if industrial unrest is to be avoided each should know the other better. No bargain has ever been considered valid and good unless both parties were pleased, and the essence of industrial peace is to recognise each other's views. It is believed that joint industrial boards composed of representatives of employers and employed in each trade should be appointed, as was recommended by the Whitley Committee, in order to discuss any new departures or to alter any old grievances. Some of the trades have several of these boards, whilst others have none. The use of machinery and the entry of women into hand trades, imply new and greatly augmented methods of production, and the labour of women needs to be taken into serious consideration in all schemes of reconstruction, for it is estimated that nearly one and a half million more women are employed since July 1914 in work previously done by men. About half a million women have replaced men in industries, another half million in commerce, over a quarter of a million on the land. and a quarter of a million in Government establishments. The National Union of Women Suffrage Society is pledged to uphold the continuation of women's employment, as well as their entry into the professions, and their right to university degrees. One of the greatest social and economic movements since the war has been the organisation of work by the quarter of a million of women on the land, who before the war numbered less than a hundred thousand. Upon the return of the men there must be some means of redistributing the women, and some form of insurance guarantee should be instituted so that the employment shall continue, or if not. then to ensure that there shall be some security of support for them temporarily. It is for these reasons that a trades council organisation in each trade should consider and advise as to rates of pay, which are the most fertile sources of labour disturbances, for these can always be settled by mutual goodwill. In order to provide the fullest information about work an information bureau or a special labour intelligence department needs to be permanently established in connection with the Ministry of Labour, the Board of Trade, or the War Office during demobilisation, and it is earnestly hoped that Labour will help to absorb those who have learnt new trades in consequence of wounds or damage to limbs. Already it is believed that over one hundred committees have been appointed in connection with the work of the Minister for Reconstruction, but what we most want is liberty of action and freedom for as

much progressive organisation as can be obtained. It is hoped that these committees will not permit the great activity in regard to agriculture to falter or fail, for it has been shown that there is a great scope for the development of rural industries. We have already learnt a lesson as to what might have happened when we were threatened with starvation and when shortage of food might already have decided the war. There will be great opportunities for providing facilities for the transport of material in rural areas when the time comes for the disposal of light railway material, motor lorries, traction engines, barbed wire, timber for housing and concrete for building material; but work must be carried on with good-will. So long as "class" feeling can be avoided—and class feeling can best be interpreted as "privilege": a standing example of this was the refusal of the Amalgamated Society of Engineers to join the other trade unions in negotiating with the Minister of National Service about man-power in Glasgow—so long will the destructive canker of strife be prevented from destroying masters and men alike. We have seen what "class" war has done in Russia; not only has it been fatal to public order and liberty, but to the whole of the industrial life of the country and to democracy; and unless we secure industrial peace the energy of the country will be consumed, and our best efforts in all other directions must be dissipated. The defensive leagues which employer and employed have already set up, the latter through the federation of workpeople representing their various trade unions, and the former by the federation of British industries grouped in the National Employers' Federation, are, in my opinion, a healthy sign, and they show the desire for fair play which makes for ultimate friendship and encourages mutual self-respect, for they are leagues for protection and defence, and it is perfectly well known that when people do not defend their interests, no justice can be secured. Before trade unions were established it is certain that workpeople were at the mercy of their employers, and before the federation of employers was formed these also were unable to defend themselves; yet it may be said that the trade unions represent mainly the skilled artisans who are only a fraction of the vast army of British workmen; but it is eminently satisfactory that out of the defensive societies representing Capital and Labour has arisen the National Alliance of Employers and Employed, a society formed to discuss common interests and composed of Labour leaders and employers, but with a neutral chairman. It is recognised that there must be a give and take—a rational compromise—if we are to profit by the lessons of the war. The form of the industrial tribunals matters little, it is the spirit of the disputants which is the essential thing. The standard of life must not only be maintained, but it must be raised in regard to Labour, and in order to do this wages must be good, but the employer is unable to pay good wages until he sells his goods, and for this he must have market facilities both at home and abroad. Imperial expansion is necessary for our trade, and protection against the foreigner has been proved to be of vital importance during this war. The common dangers to be avoided in regard to Labour are internal disputes and strife.

Law.

Among the most thoughtful practitioners in the law the war has created a very definite mental self-examination, which has revealed a rising discontent with things as they were, and this feeling has crystallised out into suggestions which have been formulated into a definite demand for changes in the law.

It is now realised that more must be done for the child, whether legitimate or otherwise, and the law in regard to adoption needs revision. The duty of parents concerns the State, and the State has, by the Children Act of 1908, recognised that a child may be removed from the "custody, charge, or care of parents unfit to be so entrusted."

In regard to the child, who must be viewed as the innocent third party to the contract of marriage and itself not a free agent, the State must ascertain whether parents are fulfilling their duty and, if they are not (upon such grounds as desertion, prolonged separation, chronic drunkenness, or confirmed lunacy), then the anomalous position of parent thus created should be terminated and the duties undertaken by others, because the permanent detriment to the child is also a hurt to the State. This matter has been seriously taken up by the Marriage Law Reform Committee.

It may be incidentally remarked that parents and children must be properly housed, and at least 300,000 homes will be needed after the war. In my opinion, the clauses of the Workmen's Housing Act of 1909, which adopted that of 1890, should be repealed if individual action is not to be paralysed in respect to housing, and the futile restrictions then set up should be removed if the occupants of cottages are not to

be pauperised by social schemes maintained out of the rates. The Government has now definitely recognised the need for action in regard to housing on a large scale, and the President of the Local Government Board has promised substantial aid, but I maintain that the interests of individual exertion and personal effort must not be discouraged.

The law of lunacy is another consideration which urgently and pressingly demands a change; public opinion is ready for it, and the war has taught the country a powerful practical lesson in regard to the care of early mental illness, The Poor Law for a long period has been waiting for the psychological moment in order to be reconstructed, and the changes recommended by the Maclean Committee will prove, if carried out, to be of far-reaching social importance; but whilst the claims of the deserving poor demand a generous consideration, the class of poor persons must not be increased by recruits from those who refuse to work and whose poverty is consequent upon idleness.

The President of the Law Society (Mr. Samuel Garrett), who represents 90 per cent. of the legal profession, has called public attention to the immediate need for changes in the law, because, as he pointed out, progress and civilisation depend as much upon the rapid and economical administration of the law as upon its just application. Indeed, he gave a significant warning that unless changes to effect these requisites were included in the scheme of reconstruction, the legal business will tend more and more to go away from lawyers into the hands of laymen, who are already approached by a growing body of disputants eager to have their affairs settled by arbitration or by compromise based on common-sense and special expert knowledge rather than to wait for the decision of the lawyers. To ensure these advantages to the public, the President suggested the appointment of a special Minister of Justice, and it can be no detraction to the carrying out of this suggestion that so many other Ministries have already been appointed. Possibly this fact would tend to favour rather than to postpone the proposed new Ministry, for it would then follow precedent which appears to be a great factor in law. It is certain that if all legal affairs were under one control, there would be less overlapping, less extravagance, and inefficiency, and there would be more supervision, concentration and expedition; at any rate, a Ministry of Justice would give effect to the unfulfilled desires of lawyers for over half a century.

There are many other points that call for legal sanction in the near future; the so-called Land Question is one. Means are needed to acquire land by public bodies for small-holdings and for the settlement of the discharged soldier as well as for cottages; also to guard against conditions that may tend to suppress individual effort and private enterprise through the formation of trusts and "combines," such as we have recently witnessed in the amalgamation of banks, insurance companies, and even the milk supply. But I fear to dwell further upon these topics, some of which (such as the protection of our trade and commerce) may be controversial, and this paper has already exceeded the limits of your patience.

DISCUSSION.

The Chairman (The Right Hon. Lord Sydenham, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., F.R.S.), in opening the discussion, said the paper covered an enormous variety of subjects, and provided an immense field for thought. The war had already produced great and far-reaching results upon the economic life of our nation and every nation that had become involved in it. For good or for evil it must profoundly affect the whole mentality of the people and their attitude towards questions of every kind—foreign, domestic, and social. It required forty years of education, deliberately designed, to bring the German people into the state of mind which made the war absolutely inevitable; but less than four years of the education the war had given had sufficed to change our whole outlook upon most great affairs. Peace-loving nations had been obliged to convert themselves into armed nations and to sink all other aims in the one great object of waging war. The case of America was, perhaps, the most remarkable of all, for America lay far distant from all the theatres of war and was not directly threatened in her own territory. The vast efforts that America had made since she realised that everything she cherished was at stake, meant a revolution in the ideas and ideals of Americans which nothing in the world, except the revelation of the German objects and the shameful brutality of German methods, could ever have brought about. For this country, and for all the warring nations to-day, the great question was: After the war will the good or the evil dominate our life? The author had emphasised the effects of the intense strain upon our troops at the front, and had said that the effects of shell-shock were both physical and psychological, and the lesson he drew, namely, that those so-called mental cases required special treatment of their own, was a very important one. It was intolerable, for example, that the soldier suffering from shell-shock or nervous breakdown, which might be quite temporary, should ever be subjected to the conditions of a lunatic asylum. He agreed with the author that the law of this

country with regard to lunacy, and the methods of treating what were called mental cases, might need substantial revision in the future. In no previous war had so great a stress been thrown upon the fighting man, and a proportion of losses which was formerly considered as disabling any unit which suffered it, had not produced that result in the present war. Men had shown greater endurance than was manifested in the wars of the past, although the trials imposed upon them had been more severe, proving that the amenities of modern life had not produced the results that might have been expected. The educated soldiers and sailors of this country had shown, during the present war, a physical and psychological endurance and a shining heroism that had never been surpassed. War, as the author said, had proved a great teacher, because it had brought home to the many what before was only realised by the few. Thus the employment of the German U-boats in ways of the blackest piracy might have the effect of regenerating the whole of the agriculture of this country, and the phrase "Back to the land" might become a reality, which, but for the war, might never have happened. With regard to temperance, it lay at the root of most social reforms in this country, and the work of the Liquor Control Board had effected a transformation. An object lesson of all that temperance could accomplish had now been provided, and the facts which the author stated proved to the hilt all that reformers had urged in the past with little result. The whole question of the safeguarding of infant life had assumed a new aspect of seriousness during the war, and the value of infant life was now understood better than had ever been the case before. With that question the subject of venereal disease was most intimately connected. That huge evil was ruinous to the birth-rate and to the national health and vigour, and he thought it was now beginning to be understood by the masses. If that was so, measures which were formerly impossible would soon be demanded by the people themselves, even if they involved, as they must, certain restrictions on the liberty of the individual. Medical science, as the author had indicated, had received a new and striking impulse during the war. Many new discoveries had been made which would be of permanent value, and the medical profession would probably have in the future largely increased powers for good in all matters relating to the public health. The effect of war upon the attitude of labour opened out an immense field for thought. Upon sound and harmonious relations between labour and capital the whole economic future of this country largely depended. There had been faults on both sides, but measures were now being taken to bring about a better understanding between Labour and Capital. The mass of the manual workers were sound at heart, although some of them seemed to be too easily misled. If, however, Socialist theories were ever translated into action, the result would be national bankruptcy and national ruin. The logical results of the doctrine of the class war, preached so diligently by Karl Marx, were now being seen in Russia, and it was interesting to note that that purely German doctrine had been propagated in Russia largely with German assistance. If this country emerged from the war with the position of the Empire safeguarded, and its rights and the rights of other nations vindicated, we should find ourselves at a new parting of the ways. We could, if we wished, rebuild our national welfare on much broader lines than before, and in time repair the heavy material losses that the nation had been called upon to sustain. If that opportunity came it would be due to the splendid heroism of our fighting men, to the cool courage and devotion of our mercantile marine and fishing population, and to the strenuous war work of patriotic men and women of all classes. For the sake of those who had fallen and suffered, the problems of reconstruction must be approached in a spirit of harmony and goodwill. As the author had said, the mingling of all classes in the field and in war work of all kinds ought to teach the great lesson of common sacrifice for the State and the Empire. If that lesson was taken to heart, if party and faction could be abolished, and if we could get rid of the party machine, which had corrupted our politics in the past and had created most of our difficulties during the war, then we could surely build up a purer, healthier, and happier national life, in which all honest workers, by brain or by hand, could share as they deserved.

Lord D'Abernon, G.C.M.G., said that with regard to drink and drink control he could re-echo the optimistic note sounded by the author. The results of the various experiments and measures which had been carried out during the last three years had far exceeded the expectation of those most intimately concerned with the work. Apprehension was felt by some that at the end of the war this country would return to pre-war conditions, but he thought that throughout all classes there was a general feeling that pre-war conditions with regard to liquor were extremely unsatisfactory, and when the men had been repatriated there would probably not be anything like the agitation anticipated by some for a return to pre-war conditions. The effect of recent work had been not only an improvement in the number of cases of drunkenness, but also a very great increase of experience in dealing with the question. Consideration of the subject must not be limited to merely restrictive operations; increased attention should be paid to constructive work, and to placing before the people healthier opportunities for refreshment and recreation. The result of the work of the Liquor Control Board would, he believed, induce many people to devote themselves to a more scientific and physiological study of the question than previously obtained, and from that might ensue the utmost benefit to the nation.

Although the measures taken by the Board were severely restrictive of the previous habits of the working-classes, in no part of the country had the reception of those measures been other than sympathetic and intelligent. Most valuable advice and guidance had been furnished by trade union leaders; he could not call to mind a single instance in which the attitude of labour leaders had been unsympathetic to reform and to progress.

MR. SAMUEL GARRETT (President of the Law Society) said the branch of the legal profession with which he was connected felt the time had now come when the proposal to appoint a Minister of Justice—first made about a hundred years ago—should be carried into effect. The appointment of such a Minister was an absolute necessity if the legal profession in this country was to do its duty to the public in the reconstruction of society which it was anticipated would take place after the war. The legal machine did not consist merely of judges and lawyers; it consisted also of a vast army of men engaged in clerical and administrative work at the Law Courts and at the various county and local courts. The management of such staffs required a Minister of Justice, with an adequate staff under him, to act as an organising and co-ordinating head. He was convinced that with proper organisation the administration of justice could be expedited and cheapened to a very great extent. One criticism made of the proposal to appoint a Minister of Justice was that such a Minister existed in fact, though not in name, in the person of the Lord Chancellor. He believed, however, that the Home Secretary also considered himself to be a Minister of Justice, and it was that dispersion of energy and functions that led to overlapping, to inefficiency and to extravagance. The Lord Chancellor had to devote a great deal of time to his work in the House of Lords, as the final Court of Appeal for this country, and in the Judicial Committee of the Privy Council; he was also Speaker of the House of Lords and his duties in connection with his judicial and ecclesiastical patronage occupied much of his time and attention. In addition to that, he was expected to manage, organise and control the legal machine, and it was impossible for one man to accomplish all that work. With reference to the admission of women into the legal profession, the war had effected an entire change in the economic status of women, and he believed it had also effected a change in the minds of members of the legal profession towards women and their aspirations to have every opportunity of earning their living. A few days ago the Law Society received a resolution passed by a local law society in Lancashire approving cordially and unanimously of Lord Buckmaster's Bill to legalise the admission of women into the profession. The Council of the Law Society had by a majority adopted the other view, although their opposition was not based on the merits of the proposal but merely on the view that it would not be fair to make such a vital change in the constitution of the profession while so many of its members were away on active service. The matter, however, concerned not only the profession but the general public, and the entrance of women into the profession would have a most vital and beneficial effect in obtaining alterations of the law with regard to the custody of children and other matters especially affecting women.

THE REV. FREDERICK MANN said he thought the severest critics of the Church would be found within its borders, but it was desirable, on account of the desire for the reconstruction of the whole fabric of our commonwealth upon the surest foundations, that there should be no feeling that the Church was contented to enjoy its privileges and at the same time deny its responsibilities. The Church suffered from the influence of custom and prestige and prejudice that had built around it certain bulwarks which had separated it somewhat from much that was good and true in the national life, but no one could read the utterances of bishops and clergy without seeing that many felt there was a great deal that would have to be turned upside down, in order to bring about that higher civilisation and those higher ideals of conduct which the Church was supposed to promote.

MR. A. H. TREVOR (Commissioner, Board of Control) said that, with reference to the alteration in the lunacy laws referred to by the author, at the present moment no one could take charge of a person for payment, detain him as a lunatic, or receive him to board and lodge, unless that person was certified. The members of the Board of Control all thought that the law was in that respect too stringent, and suggested that a limited period of time should be allowed in which a person suffering from incipient insanity and showing signs of mental disease should be dealt with by experts and have the very best treatment without attaching to him the stigma of lunacy. In the second year of the war a Mental Treatment Bill was brought forward which, for the period of the war and six months afterwards, enabled such treatment to be given to people suffering from the stress brought on by the war. It was very important that that should apply to the whole of the civil population, but if that special treatment was to be given it was important to ensure that it should be the very best treatment, and that unqualified persons should not be able to detain people as lunatics. The Board of Control had had the opportunity of laying its views before the Committee of Reconstruction and hoped that in due time its proposals would be adopted. A clear case had to be shown if any amendment by legislation was to be secured. The subject was not one which ordinary people knew very much about, and they had to be convinced that the proposals brought forward were necessary and would be beneficial. Until unanimity was obtained amongst the people interested in the subject there would not be the faintest chance of obtaining the legislation required.

Sir Arthur Newsholme, K.C.B., M.D., said that, with regard to the subject of child welfare, the author had referred more particularly to voluntary efforts to promote maternity and child welfare among the population; and, as a matter of fact, voluntary effort was commonly the pioneer of official effort, as officials were the first to recognise. Official effort came in afterwards to supplement and subsidise voluntary effort. With regard to what had been done in the past, if the quinquennium from 1871 to 1875 was compared with the quinquennium 1910 to 1914, it would be seen that the infantile death-rate had declined by 39 per cent., and the death-rate in each of the subsequent four years of life had declined by an amount varying between 41 and 50 per cent. Therefore, taking the whole of the first five years of life, there had been a very remarkable reduction in the death-rate. The damage-rate was more serious and extensive than the death-rate, and the same measures which reduced the death-rate had, during the last thirty years, very remarkably reduced the damage-rate among young children. That had been due chiefly to the efforts of sanitary authorities and of their officials—sanitary inspectors and medical officers of health. There still remained, however, a great deal to be done. Of all the deaths occurring at all ages, 28 per cent. occurred under the age of five years—that was to say, about 140,000 or 150,000 children died every year in England and Wales. Of those deaths more than one-half were due to infections, and it was public health efforts in the broadest sense of the word—including housing and improved nutrition, as well as precautions against disease—that were needed to reduce the present loss of life under the age of five years. The hope of the future lay in the co-operation of voluntary workers with official workers. Some people thought that a Ministry of Health could at once accomplish all that was required, but that was not the view of those who had been working for the establishment of such a Ministry, and who knew the need for it. They realised that after the Ministry of Health had been established there would be much uphill work to be done year after year, although that work would undoubtedly be more easily accomplished when the dissipation of energy caused by the fact that a number of bodies, central and local, were engaged in the same work was avoided. One great advance that had been made in the last few years was that it had been gradually brought home to the general public that the health of the child depended very largely on the health of the mother. The Government was now prepared to help the mother and the infant in many ways. It had arranged for the treatment of venereal disease at centres provided at the cost of the country, and assisted local authorities and voluntary agencies in certain activities by providing an equal amount of money to that spent by those authorities and agencies. Such activities included the provision of midwives and nurses in the poorer neighbourhoods, hospital treatment for special diseases of women and children, crêches, and food; and within the last month the Treasury had consented to grants being given for the maintenance of homes for illegitimate infants where the mother and child could be kept together. There was no reason why that system of the Government and local authorities or voluntary agencies providing equal amounts should not be extended in many directions.

Lieut.-Col. D'Arcy Power, F.R.C.S., R.A.M.C., said the reconstruction the medical profession had to deal with was entirely in the direction of simplification. Thousands of observations had been collected from the clinical side, and when those observations had been correlated some very valuable conclusions would be obtained. The results the medical profession was aiming at were that there should be one State examination that all medical students would be required to pass, after which doctors could take honorary titles from universities; and, secondly, that there should be one central educational establishment for London. Instead of having twelve medical schools in London there should be one large school, which could be equipped with the best teachers from all the existing medical schools. Thirdly, there should be a State examination for nurses. The College of Nurses that had just been established would prove to be one of the greatest things done for nurses for very many years.

Miss J. Halford said that, with regard to the subject of infant welfare, the man-power of the future must depend on the mother-power of the present. In all the work now being done to promote the welfare of mothers and infants, the object was the efficiency rather than the endowment of motherhood, and the work of infant welfare centres and similar institutions, as well as that of the large body of health visitors, mostly attached to local authorities, aimed at the instruction of mothers in the care of their children, and also at the education of school-girls in that important subject. It was very much to be hoped that some of the money now being spent so freely by the Government and by voluntary agencies would be devoted to the object of upholding and increasing the education of mothers.

Dr. H. Rayner said that many years ago he headed a deputation to the then Lord Chancellor advocating the adoption of a clause allowing cases of incipient and unconfirmed insanity to be treated for six months without certification, a similar clause having previously been embodied in the Scotch Lunacy Act. The Lord Chancellor adopted the clause and inserted it in a Bill, which was presented to Parliament for three successive years without being passed. At that time the Lunacy Commissioners were just as much in favour of such a provision as the Board of Control was at the present time. His experience at one of the

largest London hospitals had convinced him of the importance of treating incipient cases of lunacy in the very earliest stages, as he had found that many cases had several physical complications, the removal of any one of which would very often arrest the progress of the disease. He had urged very strongly on the hospital authorities that they should provide a special ward for the purpose of treating cases of incipient insanity, as such patients were willing to enter the hospital for treatment, but would not go to the Poor Law infirmary, and therefore became worse, and finally had to be certified. It was interesting to note that in the twelfth century in Cairo the Mohammedans had a very fine general hospital, in which mental cases were treated along with other diseases.

Dr. T. N. Kelynack said that the welfare work of the present time ought to have a physiological and psychological basis. If the work was merely war work founded on expediency it would not persist; but it would do so if it was founded on vital scientific principles. The great experiments that had been carried out by Lord D'Abernon and his co-workers on the Central Board of Control, formed a striking example to guide and govern those engaged in the work of reconstruction, and they illustrated the working out of physiological and psychological principles. War was of necessity a reversion to a primitive state, and it might be that after the war there would be habits and conditions that would tend to accustom people to primitive ways of life and thought. If Lord D'Abernon and his co-workers were unable after the war to continue their methods of control, of substitution and of suppression, there would be the danger in connection with such an agent as alcohol that it would depress and lower the powers of climbing to those loftier heights which were opening before us, and might make us willingly acquiesce in the primitive conditions now forced upon us. It was necessary to see on what foundation our principles and practice in regard to reconstruction were being built.

The Rev. C. T. Mead Allen said it was crises of unrest such as the present that offered the best opportunities for the promulgation of new ideas and for the development of old ones. Religion made its appeal to the heart, the soul and the spirit of man, but it could do so only through the mind. That being so, the period since the outbreak of the war should have afforded unprecedented opportunities for a great religious revival throughout the nation. No such revival, however, had taken place, and the great mass of the people had been left untouched by the National Mission of Repentance and Hope. The war had done a great deal to break down the individual, parochial outlook. Men wanted a God who was good and great, and nothing else would satisfy them. On the record of the Gospels alone the faith of the people must be rebuilt, and until our national life had been founded upon such a basis of faith there was no hope of a permanent and successful scheme of reconstruction.

On the motion of the Chairman, a hearty vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

COLONIAL SECTION.

A meeting of the Colonial Section was held on Tuesday, April 30th, 1918; Sir Everard im Thurn, K.C.M.G., C.B., in the chair.

The paper read was—

BRITISH GUIANA AND THE PROBLEM OF ITS DEVELOPMENT.

By Sir Walter Egerton, K.C.M.G., LL.D.

The first European settlement in the territory now known as British Guiana was established by the Dutch so long ago as 1616. Three years previously King James I. had issued a patent granting the whole of Guiana, from the Orinoco to the Amazon, to Robert Harcourt, an ancestor of the present Lord Harcourt, who, as Mr. Lewis Harcourt, was Secretary of State for the Colonies from 1910 to 1915. Robert Harcourt, however, failed to establish a settlement. The Dutch possession was maintained though frequently challenged, and for short periods with success, by the Portuguese, French, and British. until in 1803 it was finally occupied by us, and we were confirmed in possession at the peace of 1814. Though held by Europeans for over three centuries, and in the possession of the British Crown for over one, the territory is still undeveloped and in great part unknown.

Why is this? It would be a mistake to compare its history with that of other lands in the temperate zones colonised and developed from these islands. There is little similarity between the Government and development of equatorial jungles and the lands of Canada and Australia, where our race reproduces itself in all its pristine vigour, and the new population soon becomes fitted for self-government. Let the comparison then be with other lands in the tropics.

British Guiana has an area of 90,277 square miles, of which only the odd 277 are under cultivation, and this in a climate where the sun and moisture force vegetation to its maximum luxuriance and productiveness; where the indigenous forest, covering not less than seven-eighths of its extent, abounds in valuable timber and other forest produce, and is in itself a proof

of the fertility of the soil; where large areas are known to be highly mineralised, from which gold and diamonds to a considerable value have been and are being won by most primitive methods of mining.

Can I make you realise its emptiness? Let us compare the population of the Colony with that of some of our other tropical Colonies.

The population of the British West Indies, in one-eighth the area, is 1,800,000—six times that of British Guiana.

In Ceylon, 4,500,000. British Guiana, three and a half times as large, has only one-fifteenth of Ceylon's total.

The Straits Settlements and Federated Malay States, one-third the size, boast a population of 2,000,000. Fifty years ago that population was only a little more than that of British Guiana.

Why has one developed so wonderfully whilst the other has been practically standing still? It may be said that the failure of the Colony to progress is due to its want of population. That is so; but why has the population not grown more in the century of British administration? Firstly, because, though vast sums were spent on immigration, they were spent chiefly on introducing men to labour on the plantations, with little appreciation of the vital necessity of bringing women also if a permanent increase was to be attained, such an increase as would render immigration ultimately unnecessary. Then, until recently, and partly on account of the excessive number of males, but chiefly owing to insanitary conditions, the death-rate generally exceeded the birth-rate.

Is its stagnation due to its form of government, its climate, or the inherent difficulties of its physical formation? I think each of the three is partly responsible; that one, the second, has been partly overcome, and that, given a successful termination of the present war, a little sympathetic help from the Mother Country, coupled with more firmness and more active interest in its peculiar problems, should take away the reproach that undoubtedly can now be levelled at us—that after over a century's possession of a country equal in size to Great Britain, only an area less than one-fifth the size of Kent is under cultivation, and most of the remainder is still trackless forest and savannah, unoccupied except by a few nomadic Red Indians.

The coast of British Guiana faces north-east, and looks out on the North Atlantic with no land intervening between it and Greenland in the far distant north. Starting from the Venezuelan boundary in $8\frac{1}{4}°$ N. latitude, it runs south-east for 270 miles to within five degrees of the line where the Corentyne River forms the boundary with Dutch Guiana. Inland the Colony extends southwards to within one degree of the Equator. It is therefore well within the equatorial belt of perpetual summer. The climate is damp and hot, and the average temperature on the coast practically the same as in places in similar latitudes in Asia and Africa, such as Colombo, Singapore, Accra, and Lagos. In British Guiana, however, the heat is rendered much less oppressive by the refreshing North-East Trades blowing straight in from the sea. The Colony, however, was, until the latter end of the nineteenth century, considered one of the deadliest for Europeans, and its vital statistics were appalling. Recurring epidemics of yellow fever used to sweep off the non-immune portion of the population, and malarial fever was a constant scourge.

The discovery that mosquitoes are the propagators of both yellow fever and malaria—first guessed at by a British Guiana doctor in 1850—and that quinine, used as a prophylactic, is a great preventive, has changed this and rendered the Colony quite a healthy one, for those living under proper sanitary conditions.

There is some confusion of thought in speaking of climates as healthy or unhealthy. That of British Guiana is not unhealthy where the sanitation is good and the precautions modern medical science prescribes are taken. In recent years much more attention has been paid to sanitation, and year by year the insistence of the excellent medical officers of the Colony is bringing home to all classes of its inhabitants the advantage of taking such precautions.

The administration of the Government is in the hands of a Governor and Executive Council, consisting of the heads of the principal departments and unofficial members nominated by the Governor and chosen from the leading members of the community.

Legislation is entrusted to a Court of Policy, consisting of official and elected members, in which the Government has a bare majority. This legislature, however, has no power to deal with any measures involving the raising or expenditure of public revenue, which is in the hands of a third body, called the "Combined Court," formed of the members of the Court of Policy with six elected financial representatives. In this Council the Government responsible for the welfare of the community is therefore in a considerable minority. This anomalous position

is further accentuated by the Governor being excluded from all participation in the discussion of the Annual Bill for the raising of the revenue of the ensuing year, his place being taken on that occasion by the senior elected member present.

The Governor is generally an officer who has risen in the Home or Colonial Civil Service—trained throughout his life to grapple with all the problems of administration—in receipt of a very large salary, treble that of any other official, and yet the Colony is deprived of his experience and guiding voice in framing the most important enactment of the whole year. All real power—that of the purse—is placed in the hands of the elected members without giving them also the steadying burden of responsibility.

The marvel is that the Colony has done so well under such a Constitution, but under it no well-considered and settled policy for the future can be followed. Only the present is thought of, and everything is dependent upon ever-changing popular clamour.

Many of the best men in the Colony are fully alive to the desirability of a change in the Constitution, but it is unlikely that the Imperial Government will ever face the outcry that would be raised in some quarters, both in the Colony and here, to any scheme for the introduction of the usual Crown Colony administration. The grant of self-government is admittedly impossible. A middle course would be to transfer the administration of the interior to the Governor and Executive Council, leaving the coast strip to be administered as at present; this, however, would throw a considerable burden on the Imperial Exchequer for a good many years. A third suggestion, put forward recently, is federation with Canada. Undoubtedly, if such federation is ever effected, the Canadian Government would establish a local administration which had not only the responsibility for the welfare of the community, but also the power to carry out the measures considered necessary to ensure such welfare and the development of the resources of the rich interior.

Along the whole coast-line stretches a wide belt of shallow water, with numerous sandbanks, so that steamers pass out of sight of land.

The Essequebo, Demerara, and Corentyne rivers are all navigable within tidal limits, but it is only at Georgetown, at mouth of Demerara, that ocean steamers now call. Here, at spring tides, ships cross the bar on a draught of 18 to 19 ft., dragging through a foot or two of soft mud. Delay is not infrequent, but damage, except choking of condensers, almost unknown.

Mr. G. O. Case, the engineer called in to advise as to the best method of defending the coast against encroachment by the sea, and whose firm is now carrying out works in reinforced concrete to protect the most exposed portion of the coast, has recently prepared a scheme for deepening the entrance by the construction of an eastern mole, two miles in length, of the same material at a cost, including purchase of a dredger, of £250,000. For this expenditure a depth of 20 ft. at ordinary tides is expected to be secured.

The first indication of approach to the land is the change in the colour of the water from the deep blue of the Atlantic to that of pea-soup; then the masts of the wireless station and tops of the chimneys of sugar-estate factories appear, followed by the lighthouse and Old Fort. The ship as it enters the river towers above the low land.

Practically all buildings in British Guiana are of wood, and Georgetown is a wooden city. It is, however, a fine-looking, well-laid-out town with wide and straight streets.

Georgetown boasts of being the largest town in the British West Indies with a population of 55,000, or more than one-sixth of that of the whole Colony. The site is reclaimed tidal swamp well below the level of spring tides, and the problem of giving it an efficient sewerage scheme is as yet unsolved. The town is, however, well drained by a system of sluices opening on to the river at low tide.

Although well laid out in rectangular blocks, the intentions of the original planners of the city have, alas! not been followed. The riverside is overcrowded with warehouses, shops, factories, timber yards, and the poorer parts of the town have been allowed to become covered with small dwellings, with the result that from time to time disastrous fires occur, the last, in 1913, destroying a considerable part of Water Street, the chief business thoroughfare, and some thousands of tons of sugar stored in one of the premises awaiting shipment.

Fires are the great danger in all parts of the town, but, where the buildings are properly separated, can generally be confined to the place of outbreak. This was well shown in the case of the beautiful Roman Catholic cathedral, burnt in 1914 owing to the upsetting of a brazier in the tower. It is now being replaced by one in reinforced concrete, a most suitable material, and one which should in time take the place of wood in the whole of the business quarter.

The principal streets formerly had canals running down the centre, with avenues of trees on each side of these canals and on their outer sides, making four rows in all. The Victoria Regia lily was a beautiful sight in some of the canals, with its fine flowers and tray-like leaves, but the canals were also choked with grass, weeds, and refuse; the water in them was stagnant, and as breeding-places for mosquitoes they were a danger to health. They have within the last few years, with few exceptions, been filled in, and both the health of the city and its general appearance have much improved. In place of the canals are grass-bordered gravel paths much appreciated by foot-passengers.

Georgetown is on the right or east bank and close to the mouth of the Demerara River, which is about half a mile wide with a swift-running stream. For ten miles above the town on each side of the river are large and valuable sugar estates. Crossing the river a fair road runs along the coast for twenty miles, paralleled by the railway, to Parika on the Essequebo. It passes through populous villages, chiefly East Indian, who work on adjacent sugar estates and also cultivate large areas in rice, their numbers being augmented, since the lowering of the river ferry fares, by others from Georgetown and its vicinity during the rice season. It is one of the most cheerful districts to drive through. For most of the distance until the Essequebo is approached, the high sea dam shuts out the view seawards, and at high tide the roar of the surf is heard and the spray seen shooting up above the top.

Standing on the railway wharf at Parika one looks across one channel of the Essequebo at the island of Leguan, the corner of Hog Island and, far upstream, Fort Island. The estuary is here twenty miles in width. The local steamer leaves daily for Suddie on the Essequebo coast. From Suddie a succession of sugar estates formerly stretched twenty miles westward. Now only a few remain, but these are large, formed by the amalgamation of several. A large portion of this coast is now cultivated in rice. Here, too, may be seen some of the best coconuts in the Colony. Only quite recently the coast road has been extended and turned inland to meet the Pomeroon River, and give land access to the small settlements along its banks, where coffee and ground provisions are cultivated.

On both sides of the Pomeroon River and on to the Venezuelan boundary is an expanse of swamp, intersected by many river channels of deltaic formation, awaiting reclamation to transform it into sugar or rice land. It is practically untouched. Morawhanna, the headquarters of the district, is a pretty little station. The district is highly mineralised, and there are indications of petroleum on the coast near Morawhanna. It is chiefly in this district that there is the greatest possibility of an increase in sugar cultivation. Some miles up river from Morawhanna is the Government experimental station of Issarora, with a few acres of Para rubber. The trees have made as quick growth as is usual in Malaya, and have been proved to yield as generously.

From Georgetown eastwards stretches sixty miles of similar low coast, of which the first twenty-five miles to Mahaica is thickly populated, and here some of the best sugar estates and largest villages are located. Then the Berbice River is crossed to the town of New Amsterdam, with 8,000 inhabitants, beyond which lies another sixty odd miles of flat coast lands before the Corentyne River and the Dutch boundary. Nowhere, except on the chief rivers, does the occupation extend beyond a few miles from the sea. Some ten miles of the coast on either side of the Berbice River is fairly well occupied, but the remainder of the Corentyne coast and a long stretch of that between Mahaica and Berbice are very thinly settled and require drainage before cultivation is possible.

The only railways in the Colony are two coast lines, one on each side of the Demerara River, owned by the Demerara Railway Company, and a light railway eighteen miles in length built by Sproston's Shipping Company, connecting Wismar, at the head of steamer navigation on the Demerara, with Rockstone on the right bank of and above some dangerous falls in the lower Essequebo.

The eastern line of sixty miles runs from Georgetown to Rossignol on the Berbice, some two miles below its designed and natural terminus at Blairmont, opposite New Amsterdam. The first section of twenty-five miles of this line was built in the middle of the nineteenth century, and is probably the oldest in South America. Much of its rolling-stock is also, I should say, of nearly equal antiquity.

Until the West Coast line was built and this line extended some fifteen years ago, the company paid good dividends, having a remunerative contract with the sugar estates and a considerable passenger traffic. Its experience with the extensions has been unfortunate. The cost was—it is difficult to say why—very much in

excess of estimate. The lines, being ill-equipped, and the termini on the West Coast and in Berbice being in unsuitable positions, without wharves or modern facilities for handling and storing goods, failed to attract the traffic expected. The capital cost of the whole system is in the neighbourhood of £16,000 a mile, and the receipts, even with the Government guarantee of $60,000 per annum, have often been insufficient to do much more than meet the dividends due on the preferred stock. This position has lately been somewhat improved by the cheapening of the Demerara ferry fare and the extension, with Government assistance, of the West Coast line three and a half miles to Parika, on the Essequebo, at a mileage cost of only £3,500. This extension from the former terminus, in a swamp nearly a mile from the sea, to the river-bank has rendered the joint railway and steamer route the most convenient for travellers to and from the Suddie district on the other side of the wide estuary of the Essequebo.

The provision of a wharf and shipping facilities at Georgetown and the extension of the eastern line to Blairmont, the intended terminus, with similar shipping facilities, would probably, notwithstanding its inflated capital, again place the line on a remunerative basis.

A proposal of Mr. Buck, the Colonial Director of Public Works, to carry the eastern line across the Berbice River to New Amsterdam, if possible for anything approaching his estimate, is preferable to extension to Blairmont; would be of immense benefit to the Colony, and would facilitate extension along the Corentyne coast, any such extension being then certain of remunerative traffic.

In the Colony there has always been great dislike and opposition to Government undertaking works of public utility of a possibly remunerative nature, and this extends to the acquisition of existing railways or the construction of new. The success of such a policy in Trinidad, in Jamaica, in West Africa, in Ceylon, Malaya, and elsewhere in the British tropics, is ignored, but within the last year there have been signs of a change in public opinion. It is to be hoped the change *has* occurred, and that it may be permanent, for the Colony would be well advised to acquire and retain complete control of its internal communications both by land and water, so that such facilities may be used and developed solely for the public benefit and the capital and energies of local and outside capitalists focussed on developing the trade, agriculture, and undoubted mineral riches of the country.

Population.

The first adventurers found in the Guianas only scattered tribes of Red Indian nomads. They are a pleasant and interesting race, but have always shunned new-comers, whether white or coloured.

European missionaries have laboured long and devotedly amongst them and induced a few to live near their mission stations, but the bulk of the Red Indians still remain nomadic, and prefer to live, seldom more than two or three families together, in the forest or savannah far distant from men of any other race. All, and especially those who take any interest in the Colony, should read Sir Everard's delightful book, "Among the Indians of Guiana."

At present they are free to roam over all the interior, and, in addition, considerable areas near the coast and on the lower reaches of the Berbice and Corentyne Rivers have been exclusively reserved to them.

At the census of 1911 they were enumerated to the number of 6,950, but the number in the Colony is certainly not less than double.

The rest of the present population of the Colony is the result, not of spontaneous immigration, but of the efforts of the European settlers to obtain labour for their estates—efforts which might have met with much more permanent success had care been taken to introduce the sexes in fairly equal numbers.

The census of 1911 gave a total population of 296,041, increased by the end of 1916 to 313,814, and thus estimated:—Aborigines, 6,952; Europeans (exclusive of Portuguese), 3,705; Portuguese, 9,884; Chinese, 2,827; black and coloured, 152,307; East Indians, 137,850; race unstated, 336. In the twenty-one years 1891–1911 inclusive, the excess of births over deaths was only 5,332, or only 206 per annum! In the following five years to the end of 1916, a natural increase of 8,338, or 1,627 annually, took place, so that, though still very great improvement is needed, the last quinquennium shows a much better position.

The most difficult problem that has confronted the Colony from the time of the first Dutch settlements has been the increase, even the maintenance, of its population and the supply of sufficient labour for the sugar estates. At first the supply was maintained by slave importation from West Africa. When slavery was abolished other sources had to be looked for, and Madeira, China and India have all been drawn upon for immigrants to labour on the plantations.

Labour.

The curse of slavery still hangs heavily over the Colony, and accounts for the antagonism between blacks and whites. The slaves were brought from many parts of the West Coast of Africa, but chiefly from Nigeria, the Congo and the Gold Coast. In their native lands, living under a strict communal system, under chiefs with absolute powers of life and death, they led industrious lives and were excellent agriculturists.

In the last twenty years the small farmers of the Gold Coast have, unaided, created the biggest cocoa-growing industry in the world, with an export in 1916 of 72,000 tons, value £3,847,720. In Southern Nigeria the natives have, unaided, developed the palm oil and palm kernel trade to an even larger annual value.

Wonderful results, but even in these their native countries, living still under the control of their hereditary chiefs and the restraint of ancient customs, it is more than doubtful if the West Africans would be willing to labour day in and day out for a fixed wage for a European planter. The Germans have tried the experiment on cocoa plantations in the Kameruns with indifferent success, even with the help of harsh laws enacting compulsory labour with heavy punishments for defaulters—laws that would never be tolerated in a British colony.

The blacks in British Guiana cannot be relied on to supply the steady continuous labour required on a sugar estate. They do excellent work from time to time in cutting canes and in supplementing the East Indian labour in the fields, but they dislike regular work, and have a most disastrous habit of trying to take advantage of an employer as soon as they think their labour indispensable.

It must not be supposed, however, that the negro in British Guiana has not his useful place in the community, or that he always shirks heavy labour. He supplies the police and the labour for the wharves, he is an excellent mechanic, he does all the carpentering and housebuilding, supplies drivers for engines, motors, carriages and carts. He provides all the labour for the mines and the balata industry. The teaching staff of the schools, many of the legal profession and some of its most successful members, are blacks. The black population takes an absorbing interest in local politics, and the black elector controls the elections. The blacks, too, are the best represented race in the Combined Court, and rival in the fluency and length of their speeches members of our House of Commons.

The Portuguese immigrants were useless on the estates. As might have been expected, the climate proved too hot for field labour by men of European descent, and the Portuguese soon drifted into the towns and villages. They now form the wealthiest section of the community—are merchants, shopkeepers, lawyers, clerks, etc., and have secured a monopoly of the spirit trade.

The Chinese, perhaps the best agricultural labourers in the world, were introduced chiefly between 1860 and 1866. Other shipments arrived in 1853, 1874, and 1879. Fourteen thousand in all were brought, but of these only 14 per cent. were females.

The voyages averaged no less than 102 days in sailing ships fitted very differently from the immigrant steamships of to-day. Sickness and mortality were great, and the small number of females rendered impossible any substantial permanent increase to the population by their introduction. Only present needs were thought of; the labour required was obtained; it was satisfactory, and no one troubled much about the future. Thus the Chinese population has gradually dwindled until in 1911 we find the sexes approximately equal, with a total of only 2,619. Then in 1912 Chinese births first exceeded the deaths. It is satisfactory to note that this excess has since continued.

Anyone interested in the subject of Chinese immigration to the Colony should read Mr. Clementi's admirable history of the subject in his book, "The Chinese in British Guiana."

[The concluding portion of the paper, with the discussion, will be published next week.]

OBITUARY.

Henry Tylston Hodgson.—By the death of Mr. Henry Tylston Hodgson, which occurred at his residence, Welcombe, Harpenden, on May 22nd, in his seventy-fifth year, the Society loses a Fellow of very long standing, he having been elected a Life Member as long ago as 1871. He was Deputy Chairman of the Midland Railway, and also a member of the boards of several other companies. He had sat on the Hertfordshire County Council, was a county magistrate, and in 1903 filled the office of High Sheriff.

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MEETINGS FOR THE ENSUING WEEK.

Monday, June 10...Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. E. Hall, "War on and under the Sea."
Geographical Society, Burlington-gardens, W., 8 p.m. Sir Alfred Sharpe, "The Backbone of Africa."

Tuesday, June 11...Zoological Society, Regent's-park, N.W., 5.30 p.m. 1. Dr. A. S. Woodward, "On Two new Elasmobranch Fishes from the Upper Jurassic Lithographic Stone of Bavaria." 2. Mr. M. Roberts, "The Function of Pathology in Evolution."

Wednesday, June 12...Colonial Institute, Caxton Hall, Westminster, S.W., 8.30 p.m.
Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Sir Bernard Mallet, "Some Effects of the War as shown in Vital Statistics."

Thursday, June 13...London Society, at the Royal Society of Arts, John-street, Adelphi, W.C., 4.30 p.m. Sir Arthur Fell, "London and the Channel Tunnel."
Historical Society, 22, Russell-square, W.C., 5 p.m.

Friday, June 14...Sanitary Institute, Municipal Buildings, Taunton, 11 a.m. Dr. W. G. Savage and Mr. T. Lowther, "Disinfection: its place and practical application in Public Health Work."
Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. Sir Oliver Lodge, "The Teaching of Physics in Schools."

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FRIDAY, JUNE 7, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

INDIAN SECTION.

THURSDAY, JUNE 20th, at 4.30 p.m. HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, "Indian Cotton and the Cotton-Mill Industry." The paper will be read by SIR CHARLES ARMSTRONG, Chairman, Great Indian Peninsula Railway Company.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

BRITISH GUIANA AND THE PROBLEM OF ITS DEVELOPMENT.

By SIR WALTER EGERTON, K.C.M.G., LL.D.

(*Continued from p.* 458.)

It is, however, on East Indian immigration that the great sugar industry has for the last fifty years depended for its labour. The immigrants have been drawn from both Bengal and Madras, but principally from the Ganges valley. They have proved most excellent immigrants, not only on the estates, but afterwards as free citizens.

The system has been one of five-year contracts, and, after ten years, free return passages. Many, however, preferred to remain in the Colony. Here again the benefit to the Colony and to the planter would have been much greater had the numbers of the sexes of the immigrants been more nearly equal. Without doubt more would have settled in the Colony, and the natural increase would also have been greater. At present there are 20,000 more men than women in the total of 137,000, and although the female births annually exceed the deaths, such is, naturally, not the case as regards males.

It is satisfactory to note that the vital statistics of the East Indians on the sugar estates are far better than those of the rest of the population, showing that they live under healthy conditions and are not overworked.

At present the East Indians in the Colony take little interest in local politics; their numbers are steadily increasing, and are already 44 per cent of the total.

In addition to being chiefly responsible for the sugar production, they have created the rice industry, referred to later, and are gradually acquiring more and more land and taking the lead in agriculture generally.

The rapid development of the Colony of the Straits Settlements and the Malay Peninsula has been due to Chinese and East Indian immigration. The Chinese and the East Indian are the races which have so far been found to supply satisfactory immigrant labour for the development of the equatorial tropics. I know of no other races that can compete with them either as labourers for hire on plantations or on their own account. For thousands of years each of these races has learnt habits of thrift and industry in the struggle for life in thickly populated and civilised communities.

Unfortunately the Colony is threatened with a denial of immigration from either India or China, in each case as the result of ill-considered political agitation.

From India, on account of agitation in that country by a few well-meaning but ill-informed and by a larger number of disloyal agitators using misrepresentations of the indentured system of immigration as a means of creating disaffection to the Indian Government. We have here the curious position of a Government sending a mission consisting of a senior civil servant and a prominent native gentleman to examine into the working of the immigration system, praising it highly and reporting strongly in favour of its continuance, and the same Government immediately deciding to put an end to all such immigration.

From China, because the cry of "Chinese slavery" raised in this country in connexion

with immigration of that race to the Transvaal was so effective a party cry that no Colonial Secretary will now face the possible political risk of approving indentured, or even free assisted, Chinese immigration to British Guiana, notwithstanding the fact that as labourers they proved efficient, that those remaining are orderly and prosperous citizens, and that with our improved cordial relations with China, the quicker and cheaper voyage by steam in lieu of sailing ships, the actual shortening of the distance from 12,310 to 10,910 miles by the completion of the Panama Canal, the voyage being reduced from an average of 102 days to not more than forty-five, such immigration could be so much more easily organised.

Let us hope that the difficulty will be overcome, that if indentured immigration is forbidden from Eastern countries it may be possible to arrange for free immigration.

But there is the further problem of keeping in the Colony the population which is there, assuring its natural increase and attracting capital and immigrants of European race to infuse new energy and wider views into the creole population.

At present the best of British Guiana's sons leave it to seek their fortune elsewhere; many go to Canada or to the States, others to the civil services in our Colonies in West Africa. I found many good and efficient officers in Nigeria recruited from the service in British Guiana. British Guiana also furnished some of the managers and assistants on the sugar estates of the Malay peninsula in my early days, and has done the same on the more recent rubber plantations. The confined life in the small coast strip occupied has no attractions for the best of the youths; they leave the Colony and seldom return, shunning the eternal disputes between the elective section of the Legislature and the Government. All this would be altered with access to the interior.

The chief problems awaiting solution are:—

1. Conservation of the present population and increase of the rate of natural increase by improved sanitation, especially in the towns, where the death-rate habitually considerably exceeds the birth-rate.

2. Preservation of infant life.

3. Provision of good water-supply both in town and country, now for the first time made easily available by the discovery of large reservoirs of pure artesian water.

4. Execution of drainage schemes to increase the area of land in the present occupied coast strip suitable for rice and sugar cultivation.

5. Improvement of existing railway by providing it with shipping and storage facilities at Georgetown. It is the oldest railway in South America, and has worse facilities for shipping and landing cargo than when it was built in the middle of the nineteenth century.

6. An immigration scheme to provide, at the Colony's expense in the first instance, immigration of East Indians and Chinese of both sexes in equal numbers.

7. Construction of a railway from Georgetown to Rupununi Savannah, and the Brazilian frontier, tapping *en route* the entrance to Potaro valley. This would at once make cattle-ranching in the Savannahs, British and Brazilian, profitable, and create a large export trade in frozen meat from Georgetown. By immensely cheapening working in the interior, it would foster mining development in Potaro and Essequebo. Men working in the interior could then take their wives and children with them, and settlement in the interior would commence. An immense amount of land would be available for settlers from outside the Colony, who, not accustomed to the semi-amphibious life of the drained coast lands, might be attracted by the more congenial conditions of the interior.

A great development of the timber industry would result, as the line would pass through two hundred odd miles of forest, much of it containing greenheart timber.

The time required for a trip to the Kaieteur Fall would be decreased by one-half, and the expedition made much cheaper and less arduous. Where one tourist now visits the Colony to see the fall, a hundred would as soon as the railway is completed. Every visitor is a possible settler and provider of capital for developing the Colony's resources.

The line is essential for the development of the Colony, and can be justified on this ground alone; but if constructed it can hardly be doubted that, either by private enterprise or the Brazilian Government, it would be produced one hundred miles to a point on the Rio Branco navigable by large steamers, and later to Manaos on the Amazon; and in the more distant future it would certainly be linked up with the South American continental railway system, a counterpart of the nearly realised Cape to Cairo line, which twenty years ago looked an equally impossible achievement.

8. The improvement of Georgetown harbour. Some immediate improvement is necessary, but the Colony's efforts and resources should be concentrated on obtaining the interior

railway. To deepen Georgetown bar to admit ships drawing, say, 25 ft., would probably cost more than the railway, and, although there is much grumbling now, ships big enough for the present tonnage inwards and outwards are easily provided to cross the existing bar. Deep water is only reached seven miles outside the entrance, and erection of moles for that distance would take many years. It should, however, if possible, be included in the railway scheme.

9. And, lastly, such a change in the system of government as may be necessary to ensure a continuous and settled policy incapable of being defeated or obstructed by every passing gust of political agitation.

The present position makes healthy development, and the carrying out of large schemes that require certainty of action and careful finance for a long period, quite impossible. At present responsibility rests with the Government, but all power with the elected members of the Legislature, elected by only a small fraction of the community. It is a position one would expect to find in a Gilbert and Sullivan opera, but not in a British settlement. The position is very similar to expecting a Ministry in England to carry on in a considerable minority in the House of Commons. The experiment has been tried for over one hundred years, and the result is seen in a land the size of Great Britain only cultivating an area one-fifth the size of Kent. If the community is capable of self-government, then self-government should be given. If it is not, then the rational alternative is to place some other authority in a position to carry out, "without fear or favour, affection or ill-will," such measures as, in consultation with the Colonial Office, may be considered desirable for the healthy development of this valuable and rich province, for the welfare of which the British Crown and people are responsible.

Settlement.

The system of land settlement adopted by the Dutch and continued since was the same in the rivers and on the coast. There were no roads, and access to estates was at first by water only; hence each lot was given a frontage on the river or foreshore, and the land behind left unalienated. Owing to extension of cultivation, sea encroachment on front lands, or their gradual exhaustion, owners applied for and obtained title to additional "depths" behind their original allotments, so that now a lot may be only 100 or 200 yards wide, but anything up to five or more miles in depth. The land, when first opened, was covered with courida or mangrove on the frontage, with heavy forest behind. The adopted method of opening up was always the same. Deep and wide trenches or canals were cut from the sea or river inland, one on each side of the lot for drainage, and one down the centre for irrigation and navigation.

The earth excavated formed raised banks or dams, which prevented influx of water from either side. At the river or sea front and at the back other dams were thrown up, so that the estate was completely enclosed. Subsidiary trenches and dams, parallel to front and back dams, divided off the land into rectangular fields of convenient size, so that access by water was facilitated to all parts. In the earlier days all transport was by water. All internal estate transport is still so conducted, and the canes never have to be carried more than about 100 yards. The names of the estates perpetuate the memory of the successive occupation of the Colony by Dutch, French, and English. Thus adjacent estates in Demerara bear the names of Mon Repos, Triumph, and Beterverwagting.

To control the drainage and irrigation water numerous sluices—for which the old Dutch name of *koker* still persists—had to be constructed. The chief were those in the river or sea dam to allow passage of boats bringing supplies and taking away produce and to provide for drainage. A belt of mangrove and courida was always left to protect the front dams.

Water was required for irrigation. The back dam obstructed the flow of the inland water, and as a long line of estates grew up the continuous back dams held up this water, and it was admitted to the cultivation as required. But this supply was unreliable and insufficient, so that gradually estates combined together and, with the help of the Government, the land behind the estates was also empoldered, and the shallow reservoirs thus constructed now run back to where undulating country commences and effectually prevent the inland extension of cultivation or settlement. A very efficient system of irrigation has thus been created.

Georgetown and the estates and villages depend on these reservoirs for water for domestic purposes, supplemented by rain-water collected from roofs.

In 1911 the autumn rains failed and a great drought occurred. At the instance of Sir Charles Cox, the acting Governor, the first deep-boring machinery was ordered, since supplemented by much additional plant. Deep

artesian wells have been sunk and ample supplies of exceptionally pure water struck in Georgetown and on the greater part of the coast, but so far have not been fully utilised owing to the absence of a staff skilled in the fixing of strainers and other apparatus for preventing the choking of the tubes. Most of these wells are "gushers," and the best supplies have been found at depths from five to eight hundred feet.

Sea Defence.

So long as the foreshore is left untouched it changes little, and the tendency is towards gradual silting and extension seawards, but the alteration of the natural drainage, the more recent concentration of this drainage into a smaller number of outlets with greater discharge, the cutting down of the protective belt in some places and its erosion in others, have led to constantly increasing trouble with the sea defences. So serious has this become that the coast is now divided up into sea defence districts, for which bodies of commissioners, presided over by the Director of Public Works, are responsible. A general sea defence acreage tax is levied, the proceeds of which are supplemented by large Government grants and loans. The most exposed portions of the coast are now being permanently defended by reinforced concrete facing to the dams, and groynes of the same material are being run out seawards to stop erosion.

Roads.

At first the only method of communication was by water, but the earth thrown out of the canals formed raised dams easily converted into roadways, and each estate was compelled by law to maintain a road across its frontage connecting with similar sections made by the adjoining estates. The bits of road were often not in the same alignment, and then connecting links had to be constructed on the dams running at right angles. From time to time encroachments of the sea compelled retirement, and new sections had to be formed with similar connecting links joining on to the old portions left in use. Until the advent of motors this zigzag trace was negotiated by vehicular traffic without much danger, but a drive now with a negro chauffeur at the wheel, oblivious of the laws of centrifugal force, is not without excitement. Cars are frequently overturned; many have been the immersions in the deep roadside trenches, and even fatal accidents are not uncommon.

In the whole of this coast zone there is no stone. In places along the coast are what are known as "shell beaches," banks of finely broken up shells from the shell-fish that live and breed in the adjacent mud flats. The surfacing of the dams which form the coast road with hard material suitable to withstand wheeled traffic was therefore a difficult problem. It was solved by the early Dutch settlers in a simple and excellent way. They burnt heaps of the clay soil into brick earth, which spread on the roads—coarse lumps below with finer material on top and faced where possible with shell from the beaches—gives a really excellent surface not unlike the laterite roads of Ceylon and Malaya.

For heavy traffic, however, something harder is now required, and broken granite is brought to Georgetown from the quarries up the Essequebo at Dalli and Mazaruni.

When slavery was abolished the bulk of the black population ceased to labour on the estates and many of them were abandoned. Some were bought by philanthropists in England and presented to the former labourers; some were otherwise acquired by the negroes. Village sites were laid out on the front lands and the people settled on them. The land adjoining the village was kept as common grazing-land, and the back portion of the old estate divided up into farms, to which journeys are made by canoe. This location of dwellings far away from cultivation is very disadvantageous, facilitates predial larceny, and encourages careless and insufficient cultivation, as so much time has to be spent in journeying to and from the farm. Residence on a farm, however, is objected to under present conditions owing to the certainty of increased contamination of the drinking water. So extensive is the canal system of each estate and village that a pleasant day can be spent "going aback" in a punt or canoe.

The only way of travelling into the interior of the Colony is still by water. The mighty Essequebo and its tributaries furnish the chief arteries of communication, running right through the Colony. Above tidal influence, rapids, cataracts, and falls abound, making travelling slow and very expensive. The country is one huge forest with patches of wet savannah or grass within twenty-five miles of the coast, and in the far interior, on the borders of Brazil, larger tracks of dry savannah extending to a total of some 10,000 square miles and affording excellent grazing for cattle and horses. These savannahs adjoin a much larger area of similar country over the border.

At present only a few ranching titles, terminable, as is usual, within a short period, should the land be required for closer settlement, have been issued. Three or four ranchers own large herds of cattle and a few horses. They would be well off if they had a market, but it is impossible to take the beasts to the coast, and sale over the boundary in Brazil is prevented by a prohibitive duty. A few are smuggled over the border.

A fresh attempt is now being made to cut a practicable track from the Kaieteur plateau through the forest, down which the cattle could be driven to a point on the Essequebo or Demerara, from which water transport can be provided. The problem is not an easy one. It is not merely a question of the provision of a practicable track, but also of grazing and resting-places on the way.

Journeys to the interior on business are tedious. In all the rivers, as soon as tidal influence ceases, rapids begin, and ridges of rocks run across, holding up the water behind. The fall may be only a few inches or it may be many feet. The boat has frequently to be dragged through the rapid or unloaded and dragged overland round a fall. Thus boats generally travel two or three together, so that the crews may help one another. Ten miles up stream is a good day's journey. Even the return journey is slow, as it is not safe to "run" many of the falls.

To those on pleasure bent, with ample time, such trips are full of enjoyment. There is an ever-changing scene of forest and hill and mountain. Large flowering trees of many colours, blue and scarlet macaws, screaming overhead or in the trees on the banks, duck and other water birds, including the great Muscovy duck, are frequently seen. Otters, in schools, race up the stream on the appearance of a boat, until, wearying of the struggle, they dive and reappear a quarter of a mile below. At night you may be wakened by the howling of the great red baboons—if near, a truly astonishing noise, and plainly audible for many miles—or by day a glimpse may be got of a group in the top of one of the highest trees. Day after day the traveller passes on with thick forest on either bank.

The trees on the riverside are clothed, choked, in an impenetrable tangle of creepers, the yellow allamanda and a purple bignonia being most striking objects. Once or twice in a day you may pass a small Indian clearing on the bank, or, in the mining districts, a "landing" with a Chinese shop and a scarcely visible foot-track leading to a mining location, or, perched on a high bank, a balata company's supply depôt.

Mining.

Over a very large part of the interior, from the Venezuelan border to the valleys of the Essequebo and Potaro, gold and diamonds have been found in rich and shallow alluvial deposits. Most of the mining has been and is done by small men washing the river gravels in the primitive way common over all the world. These miners are almost entirely recruited from the black population. In places European prospectors attracted by the rich finds of alluvial workers have located lodes. Companies have been formed, capital raised, and expensive machinery taken at immense cost up the rapids; generally the capital has been dissipated in preliminary expenses, machinery, houses and other equipment, leaving little for working expenditure, and gold has not been secured in sufficient quantity to pay the great cost of running a mine in the interior of a country without communications, without facilities for transport of men or material, and where all food and other supplies must be imported and brought up from the coast. Two companies in fairly accessible localities in the Potaro district have done well in dredging in the Minnehaha and Konawaruk; and the former has also a very promising proposition at Eagle Mountain, with a large quantity of proved alaskite formation similar to that of the Yukon district. Its development awaits the conclusion of the war.

The chief river valleys exploited up to the present are the Barima and Barama in the North-West District, Cuyuni and Mazaruni, both affluents of the Essequebo, and the valleys on both sides of the watershed dividing the Mazaruni and Essequebo, and again the valleys in the watershed between the Essequebo and lower Potaro, below the great Kaieteur plateau. No successful mining has been done east of Essequebo, though some gold has been found.

Gold-mining has now been carried on since 1884, when 250 oz. were exported. The output rapidly increased until, in 1891, over 100,000 oz. were produced, and the annual export continued to exceed that figure for twelve years. It has never reached it since, but at the same time seems likely to continue above an average of 50,000 oz. As recently as 1913 some rich new deposits were located, with the result that the output jumped up to over 82,000 oz. Since the war gold-mining has much decreased owing to the great

rise in cost of supplies and the much higher wages to be earned on the coast.

The free adventurous life on the rivers and in the forest has a great attraction for the young blacks of the labouring classes, and the Negro, like the European, is content to work for little and undergo great hardships if there is a remote chance of sudden riches by a lucky find.

At Christmas all these men insist on returning to their homes on the coast, and Georgetown and its vicinity is then full of them driving about in hired carriages, decked out in fine clothes, and determined to make up for the privations and dulness of their bush life.

Since 1884 over 2,500,000 oz. of gold, valued at more than £9,250,000 sterling, have been exported, nearly of all it the produce of shallow placer workings. Only 70,000 oz. has been obtained by quartz milling.

Diamonds are found in the far interior of the Mazaruni and other rivers, often together with gold. At first they were not recognised. The production since 1901 has totalled 125,000 carats. The output has varied greatly, from only 2,000 carats in 1907 to a maximum of 16,400 in 1916, probably due to prohibition of export in 1915, but the average of the four years 1913–16 was in excess of 11,000 carats. This weight is greater than the total of any previous year, so that production tends to increase. That an increase should occur during the war is extraordinary, as the cost of maintaining supplies on the distant diamond-fields has at least doubled.

It must be remembered that all this mining—gold and diamond—is being carried on in a thick tropical forest country by black prospectors, natives of the Colony, who start without the slightest knowledge of geology and acquire all their skill from their fellow-workers. Gradually a class of very efficient prospectors and workers has been evolved, but they work with very inefficient appliances, are unable to sink much below water-level, and in a country where the most highly-trained white prospector would find the greatest difficulty in discovering and following up indications of the metal or stones. Few of the mining districts can be reached in less than a week, and some require two, three, or even four weeks' toilsome journey. These journeys, after the first day, are done in small open row-boats, very strongly built, similar to the "surf" boats used on the open sea beaches in West Africa, and manned by a crew of eight or ten paddlers. Oars are never used, as they could not be manipulated in the rapids or in the narrow channels of the smaller "creeks," as the affluents of the main rivers are locally called. It is in this river traffic that the aboriginal Indians alone mingle in the life of the Colony and forsake their habitual isolation. Some of the boats have Indian crews, and more have Indian or "Boviander" steersmen. A "Boviander" is a man of mixed Indian and Dutch blood. On the skill of the steersman and bowman the safety of the travellers depends, especially in "running" the numerous rapids. They all pass strict tests, and no boat can be taken up or down without certificated men.

All supplies for the mines have to be taken from the coast. Most are imported. Biscuits, salt pork, beef, and fish are the chief staples. There are no towns, no villages, no settlements from the time the tidal influence is left behind, no means of land transport except on men's backs. At the most used landings and at the larger locations there are shops, generally kept by Chinese, at which supplies may be bought and gold-dust sold or advanced upon. That is all. Where mining has been going on in one place for some years a few vegetables may be seen growing, but it is one of the most regrettable features of British Guiana mining that it has led to absolutely no opening up and settlement of the interior, and this is entirely due to the difficulty and costliness of living there and of maintaining communication with the coast under present conditions. The mining locations are spread over so great an area, are so shifting, and the country is so broken and cut up by rivers, that nowhere has wheeled communication been made possible, nor can beasts of burden be introduced. A considerable sum was spent in cutting a track for sixty miles, through the forest of the watershed between the Essequebo and Mazaruni, from Bartica on the navigable Essequebo to the Caburi minefield. This is known as the Caburi road. It has never been used except by a few foot-passengers, being quite impracticable for wheeled traffic, and there are no resting-places. The traffic still goes by the river route.

A similar history attaches to other attempts at road-making in the interior. As soon as mining ceases in any locality the place is deserted, the tracks from the rivers close up again, landings become overgrown, and King Jungle resumes his sway.

Bauxite.

Although mining has hitherto been confined to gold and diamonds, the prospect of the rapid development of a branch of this industry, much more profitable to the Colony, is now in sight,

owing to the discovery in British and the other Guianas of some of the largest and richest deposits of bauxite in the world.

As long ago as 1897, and again in 1910, Professor Harrison, the eminent geologist, who has long held the appointment of Professor of Science and Agriculture, reported the existence of extensive deposits of exceptional purity. The discovery attracted little attention, however, until five years ago, when the Northern Aluminium Company of America applied for leases of areas containing such deposits. Aluminium has, since the outbreak of the war, been found to be so essential for munition and aircraft purposes that the British Government stipulated that any company working the deposits must be under British control. After long negotiation a company has been formed by the Americans interested to meet Government requirements, and the first cargo of bauxite has left the Colony. This company has acquired large areas of land from private owners and leases of a considerable extent of Crown land in the vicinity of Wismar, at the head of navigation on the Demerara River, near the terminus of the little railway connecting the Demerara and Essequebo Rivers. Ships drawing sixteen feet can reach the workings sixty miles above Georgetown.

The bauxite deposits have recently been traced almost from the Venezuelan boundary right through the Colony to the Dutch border. Further deposits have been located in Dutch and French Guiana, and the Guianas probably contain the most extensive deposits in the world, and some in very accessible positions. Should the industry develop on a large scale, local electrical treatment of the raw material with power obtained from one of the great waterfalls is sure ultimately to take place.

Balata.

Another industry that draws men to the far interior is one known by the unpleasing title af "balata bleeding." Balata is the coagulated latex of the balata tree (*Mimusops globosa*), and is a very similar substance to and substitute for gutta-percha. It is used for machinery belting. The tree is found over wide areas of the forest right down to the farthest south, and as its value is generally higher than rubber its collection is a profitable work. The industry is controlled by the Consolidated Balata and Rubber Company, the survivor and absorber of many other companies. In the spring of each year parties are organised and sent up all the rivers of the Colony. They are kept supplied from up-river depôts, and return in the autumn with the dried sheets of balata. Last year the total exports—the greater portion by this company—exceeded 1,500,000 lb., and as its present value is about 4*s.* a pound; the year's crop is worth about £300,000. The cost of collection, however, is considerable.

Timber.

But mining and balata bleeding are not the only industries that take men into the forest. Timber-getting is carried on to a considerable extent for firewood, shingles, charcoal, sleepers, etc. In the case of greenheart the work extends even somewhat beyond the tidal belt. Difficulty of transport, however, confines this industry, except in the case of the Essequebo, to below the falls. Greenheart, the most valuable timber for all under-water structures, is largely exported, and was used for the Panama Canal works.

On the coast lands practically the only products that are much grown are sugar, rice, coconuts, and limes. Coconuts do fairly well. The trees are seldom carefully cultivated, but left ill drained and choked with grass, weeds, etc. Limes flourish all along the coast and river lands. There is some hope of success in production on a commercial scale of lime-juice and citrate of lime. An enterprising private firm has a factory in Berbice; another factory is working on the Essequebo, and a Government factory in the Suddie district. With the assurance of a steady price lime cultivation should become a profitable and popular village industry. The length of the sea voyage to the States and Canada precludes the export of the fresh fruit.

In the lower river reaches are large areas suitable for coffee and cocoa, and except close to the coast, where the subsoil is sour and salt, practically the whole Colony, up to an elevation of 1,500 ft., is suitable for rubber cultivation. Whether, when the price of rubber falls to near the cost of production in Malaya, say between 1*s.* and 1*s.* 6*d.* a pound, it could be grown profitably with the dearer labour available in British Guiana may be doubtful, but the rubber industry has flourished now for over ten years, and there seems little danger of prices falling below 2*s.* for a considerable time. That rubber will grow as rapidly and yield as bountifully in British Guiana as in other countries in the same latitude has been proved both on the Government experimental plots and on a few small private plantations. Unfortunately, in no single case has a sufficiently large area been planted and maintained in cultivation until the bearing age to

pay the cost of a superintending staff and estate organisation. In several cases areas have been cleared and planted, but have generally, owing to lack of funds, been allowed to relapse into jungle. In British Guiana only one plant is carefully cultivated, and that is the sugar-cane. A recent example of the devotion to sugar, to the exclusion of other agriculture, is given in the alteration of the name of the Planters' Association to that of "The Sugar Planters' Association," apparently as an advertisement that no other branch of agriculture is worth local consideration.

This present attitude must be attributed to the great prosperity brought to the sugar industry and the Colony by the war. Before the war, although large and well-managed estates, with plenty of capital and well-equipped with modern machinery, managed on a series of years to do well, others did not, and many men looked about, in a half-hearted way, for other products to take its place, with the result that both coconuts and rice cultivation extended. In 1884, 98 per cent. of the Colony's exports consisted of products of the sugar-cane—sugar, rum, molasses. All other exports only reached £43,000 in value! In the same year sugar-cane products exceeded in value £2,000,000 sterling. Then a change began.

From 1892 onward less than 80 per cent. of the total exports came from the sugar-cane. This was not due, however, to increased cultivation of other products, but to the rapid development of mining, to the growth of the timber industry, and to the decline in price of sugar. It is only within the last decade that the increased exploitation of balata and the very satisfactory development of rice cultivation have taken place.

The value of the sugar products exported in the three war years is considerably greater than in any year since 1884, beyond which my records do not go back. In 1916 it approached £2,750,000 sterling, other produce amounting to £630,000. While in 1884 produce of the Colony other than that derived from the sugar-cane only amounted in value to £43,000, in 1917 rice alone was exported to six times that total.

The history of the rice industry is a curious one, but there is not time to tell it here. Suffice to say it struggled slowly upwards to success against much opposition. It was created by the efforts of the East Indians, and now not only supplies the whole requirements of the Colony, but a surplus of over 13,000 tons for export to the West Indian Islands.

Kaieteur.

No paper on British Guiana is ever likely to be written without a mention of the Kaieteur Waterfall. If access to the interior is ever made easier the Colony should become a favourite haunt of the tourist. There can be seen equatorial forest vegetation in all its pristine beauty. There, too, are sights not equalled elsewhere, and, though in the damp heat of Guiana many may not care to take trips involving much physical exertion, given a few of the conveniences looked for in modern life thousands would certainly visit Kaieteur and some the more distant Roraima.

Only a brief mention of Kaieteur is possible here. The return trip from Georgetown takes nine days; at present there is a good deal of "roughing it," and the cost is about equal to residence in a good New York hotel. The first day is spent in a small river-boat from 8 a.m. to 4 p.m. or later, on a sixty-mile run up the Demerara; thence twenty miles on the little railway connecting this river with the Essequebo. The second day Tumatumari on Potaro is reached in a small and noisy motor-boat. On the third morning there is a run of two hours in a motor-boat, a walk of four miles round a series of rapids, and the remainder of the journey on that day and the fourth in an open boat with a crew of Indian paddlers. On the fifth morning, after a rather arduous climb of one and a half hours through heavy forest, the traveller emerges suddenly on the Kaieteur plateau. The rest-house here and those occupied on the previous two nights are of a very primitive description, but it is to the enterprise of a private firm, Messrs. Sproston's, that the facilities, such as they are, exist on Potaro, and I fear their provision has not been a profitable work. Five minutes from the rest-house the edge of the fall is reached. The scene is astonishingly peaceful. There is a placid and clear river—like the Thames at Henley—quickening its pace as it nears the edge, with here and there a grass-covered rock piercing its surface; the near bank is gently sloping rock partly covered with brushwood and low trees. On the far side high forest. There is no deafening roar as at Niagara, the bottom of the fall is so distant, over 800 ft. It is difficult to realise such a vertical height. Five times the height of Niagara, four times the height of the London Monument, or just twice the height of the top of Hampstead Heath above the level of the Thames! Thus the sound is softened and rises and falls like the surge of the sea on a distant rocky shore.

After the first shock of the immensity of the drop the visitor's attention is drawn inevitably to the gorge. Thickly-wooded hills rising well above the plateau press in on either side until they melt away in the dim distance. Nothing but forest, but such forest, and with light and shade playing on the varied hues of the foliage, this gorge forms a wonderful picture of tropical growth from a unique vantage-point of view. In the centre of the gorge below one's feet is a boiling basin, and beyond the apparently dry rocky bed of the river with an occasional pool. The river forces its way for some miles, out of sight and far below the huge rocks piled helter-skelter in the bottom of the gorge.

On the side the fall is approached—the left bank of the river—the plateau has been carved out in a rough semi-circle, so that by scrambling about half a mile through the forest a point can be gained almost facing the middle of the fall. Here one can sit on the edge of the precipice in comfort in the shade and see the full drop to the pool beneath, at a distance, I should say, of about one-third of a mile from the falling water. Sometimes the fall is hidden by the mist rising from below for days together, but the view generally clears between 10 a.m. and 3 p.m. I have travelled a fair amount, and never have I seen any sight approaching this in beauty. From this position the sensation is of being below the top of the fall, but this is deceptive, as is realised when it is noticed that the river is visible for the whole of the long reach above the fall. The setting is perfect; the forest is untouched; in the distance the highlands and some of the mountains barring the way to Roraima are visible; the placid river glides towards the edge and the amber-coloured water curves over, whitens, and quickly breaks up again and again into arrow-headed gauze-like points which seem to descend slowly and dissipate into vapour before the boiling pool beneath is reached. At the sides it can be dimly seen that there is a great cavern behind the falling water, in which each night thousands of swifts take their rest. The photographic slide I shall show you gives but slight idea of the reality. Colour and movement are lost, and it is only to those who have been there—like our Chairman, who was the first European to visit the fall, and the first to climb Roraima—that a photograph can recall the reality.

Roraima.

Mr. Clementi, the present Government Secretary, has proved that the quickest and easiest way to Mount Roraima is *viâ* the Kaieteur Fall and a day's journey up the river to Holmi and thence overland.

Like Kaieteur, Roraima is unique. It is a flap-topped mountain over 8,000 ft. high, its sides rising some 5,000 ft. above the surrounding country, the top 2,000 ft. being a perpendicular cliff. It was long thought to be inaccessible until Sir Everard im Thurn found a way up along a narrow ledge. Mrs. Clementi accompanied her husband to the summit in 1916, and is the first woman to make the ascent. The journey beyond Kaieteur, after the first day on foot, is at an elevation of over 2,000 ft., and a cooler and more pleasant atmosphere is soon reached. The route is largely through savannah country.

Fish.

The rivers of Guiana are full of edible fish of excellent quality. The chief are the lowlow, haimara, paku, arawana, and arapaima. They are all as food fully equal to good sea fish. The arawana, still only procured by shooting with a bow and arrow, is excellent. I spent one afternoon in a canoe with two Indians, who thus secured four fish averaging about 5 lb. weight. To do this they had over twenty shots. The arrow has a long shaft; on a hit being made the fish dashes off, from the shallow where it has been sunning itself, into deep water. The shaft soon bobs up and is followed. When within reach a violent thrust downward is made to drive the barb well in. When again grasped the fish can be lifted out.

The arapaima is the great food fish of the Amazon, and is rarely found in the Colony outside the mouth of the Rupununi. In that river it is plentiful, as the Indians prefer the smaller and more delicately flavoured arawana, haimara, etc. The arapaima reaches the tremendous size of over 400 lb. It is caught with heavy lines like those used in sea-fishing, but I had an extraordinary afternoon's rod-fishing on my trip to the Brazilian boundary in connexion with the proposed hinterland railway. We had two tarpon rods between three of us—my aide-de-camp, Mr. Bland, the railway engineer, and myself—and we landed seven fish, one weighing just 200 lb., and the seven just over half a ton. With heavy tarpon rods and lines each fish took on an average twenty minutes to land. Fortunately for my reputation I had a camera with me, and photographs of the catch accompanied an article I sent to the *Field* on the subject. On the following day I caught a 75 lb. fish with a salmon rod in about three-quarters of an hour.

The presence of arapaima in the Rupununi and of a very vicious little biting flyfly, one of the pests of the Amazon, are held to be proofs that once the waters of the Rupununi valley drained into that river. Even now the height of the divide between the sea and the Amazon valley is only some 250 ft., and in the wet season the waters of the two river systems approach within half a mile of each other, and Indians drag their canoes across the watershed. If ever the middle Amazon is to be given a route from Manaos, more than a thousand miles shorter than the river route to the United States and Canada, surely it will be over this low watershed to Georgetown. If the line is constructed to Manaos its extension to meet the southern railway systems of Brazil and the Argentine can only be a question of time. The Takatu, on the Brazilian boundary, runs into the Rio Branco, one of the chief tributaries of the Amazon, joining that river near Manaos.

The British Guiana section, if taken from Georgetown to the junction of the Ireng with the Takatu, to which point launches easily ascend, would be some 340 miles. Its construction presents no engineering difficulties, and the cost of a metre-gauge line was estimated by Mr. Bland at only £3,500 a mile. Mr. Buck, the Colonial Director of Public Works, has recently investigated the problem afresh, and recommends a slight variation of the route at Georgetown end, but confirms Mr. Bland's estimate of mileage cost.

I will not here discuss the relative advantages of the two routes beyond remarking that by Mr. Buck's route the distance to the Takutu is increased by twenty-six miles, a very serious consideration as traffic increases, and that Wismar, the probable headquarters of a great bauxite industry, would be left without any other communication with Georgetown than the lengthy river route.

Mr. Nunan, the present Attorney-General of British Guiana, had done much to boom this attractive railway project before my arrival in the Colony, and succeeded in raising great enthusiasm on the subject. Many of the leading men see in this line, without the Manaos extension, a solution of the problem of the Colony's development. I agree with them, and I had hoped to return to England in August, 1914, to press the subject on Mr. Harcourt's attention. I knew he realised its importance, and it would have been fitting that he, one of whose distant ancestors received a grant of the country from James I., and twice attempted to take possession of his property, should be the Minister finally to render the development of its rich interior possible.

The question of financing its construction, however, bristles with difficulties. In the Colony there is much divergence of opinion. The planters of the coast fear the loss of their labour, and urge that the scheme must be accompanied by a costly supplementary one for the introduction of many thousands of settlers. Another section is against construction by Government, refusing to see that it is a project impossible for private enterprise as there is no prospect of paying even working expenses for at least ten years. These people are misled by concession hunters, inexperienced and over-sanguine, to take a charitable view of their promises, who offer to construct the line on easy terms without having the remotest chance of finding capitalists to finance their proposals. The line, if built, must be built with Government money. The Colony cannot afford to carry out the work.

Here seems to me a project eminently worthy of the attention of the Empire Resources Development Committee, not, however, with a view to further development at the expense and for the benefit of the Mother Country, except indirectly. Where would Britain be without her oversea possessions? Taking the tropical Colonies alone, it would be instructive to calculate how many millions are annually poured into the Imperial Exchequer as income-tax, now swollen further by excess profits duty, on receipts by her citizens from their oversea properties, and, on their decease, by death duties thereon. Is it too much that in return the Mother Country should advance, as in the case of the Uganda railway, the means of giving the people, both of the Colony and of the United Kingdom, a chance of proving their ability to take advantage of the opportunities so offered?

Until Mr. Chamberlain ruled at the Colonial Office our West African Colonies were in a much worse state of stagnation than British Guiana. Under his guiding hand, and with financial help from the Treasury, railways began to be pushed up from the coast in each of our West African possessions, with the result that nowhere is there more rapid progress to be seen than in those possessions. Without the progress so ensured we should now be without urgently needed vegetable fats, without our chief source of cocoa supply, and without the troops that have borne the brunt of the fighting in sub-

duing Togoland, the Kameruns, and German East Africa.

Within ten years of the completion of a railway to the savannahs in the interior the cattle traffic should alone be sufficient to cover working expenditure. But great development in mining, the timber trade, and in the exploitation of other forest products may be looked for, as well as the beginnings of agriculture, nor is it likely that with a railway on the Takutu the Brazilians could long resist extending it to Manaos, or at least to a point on the Rio Branco, and thus secure the immense advantage of a direct route to the North Atlantic at Georgetown. With such an extension there would be no further anxiety regarding the financial prospects of the line.

The inhabitants of British Guiana boast of their loyalty. There are many who recall with delight the visit of His Majesty when a midshipman on the "Bacchante." The visits of Her Highness Princess Marie Louise in 1913 and 1914 were made occasions of great demonstrations of loyalty and affection to the Crown and Royal Family. When the war broke out the Colony hastened to present offerings of sugar and rice. Large sums, too, were collected and transmitted to the Prince of Wales's and the Red Cross funds. Collections were made for aircraft, many consignments of made clothing sent to Queen Mary's Needlework Guild, and subscriptions collected for many other of the numerous funds in connexion with the war. Many men went home or to Canada and joined the forces being raised, and British Guiana has sent her contingents, raised locally, to serve in the British West India Regiment.

The war happens to have brought great prosperity to the Colony by raising the price of its staple products, but it has also brought sorrow to many homes there, for the youth of the Colony have taken, and are taking, their part in the great struggle for freedom.

DISCUSSION.

The Chairman (Sir Everard im Thurn) said he had listened to the paper with the greatest interest. As a matter of fact, it probably was even more interesting to him than to anyone else present, because it carried him back into the forests of Guiana, where he spent twenty years of his life, and he could vouch for the accuracy of nearly everything the author had said about the interior of the Colony. His knowledge of the coast land was not as great as his knowledge of the interior, but he took it that the main object of the paper was to call attention to the development of the interior. From early Dutch times down to the present day the coast lands had been adequately developed, and attention must be turned in the future to the interior. Sir Walter Raleigh, rather more than 300 years ago, dreamed of the rich empire of Guiana, and Sir Walter Egerton, who had recently been wandering over the savannahs, believed that by proper development that dream could be made to come true, and the interior of Guiana be made a valuable asset to the Empire. The task, no doubt, would be a difficult one. It was the old story of digging for buried treasure. Guiana could not be developed by those who occasionally went there as visitors, even if they scratched the surface and dug up the gold, diamonds, balata, and other natural produce. The whole scheme must be thoroughly worked out; in fact, the land must be dug as in the old stories of digging for buried treasure, and only then would the treasures be obtained that were really there. That was a very serious and difficult undertaking, and he thought the author was right in saying it must be undertaken as an Imperial task. The resources of the Colony itself were probably not adequate to develop the hinterland properly, but when the war was over, and the Empire again had time to think about the development of its distant possessions, then British Guiana might be developed by some system of introducing free labour—East Indian, Chinese, or from other countries—and a proper system of land tenure. That system would be difficult in some ways in Guiana, owing to the uncertainty about the rights of the Indians in the land, but that difficulty could be overcome. Not only was population needed, but adequate systems of communication. The rivers only went through certain parts of the Colony, and a railway was required to connect one river with another, from the coast to the Brazilian frontier, in much the same way as the author had indicated. During the war, however, and probably for a long time afterwards—for the Empire would have a great deal to do in other ways—he was afraid the development of the interior of British Guiana would have to be postponed. There was one point in the paper that he wished to correct for the sake of historical accuracy. The author had given him the credit of being the first European to visit the Kaieteur Waterfall, but that was not the case. The Kaieteur was discovered by Mr. Barrington Brown about the year 1872, and it was Mr. Barrington Brown's book, "Canoe and Camp Life in British Guiana," notices of which appeared in the *Saturday Review* in 1877, that was one cause of his going out to Guiana. About two years after the Kaieteur was discovered, Sir George Young, who was in Guiana at the time in connection with the inquiry into the East Indian labour there; Colonel Webber, who was in command of the troops then stationed in Guiana; and a certain well-known planter, John Bascombe, went to the Kaieteur and anteceded his own visit, which was in 1878. Therefore, although he could claim the credit of having been the first to see the top of Roraima, he could not claim the credit of being the first European to see the Kaieteur.

Mr. C. Sandbach Parker, C.B.E., said that, as one who had lived in British Guiana for some years and had been identified with the Colony for the whole of his business life, he had listened to the paper with the greatest possible interest. About six years ago, when he returned from his last visit to British Guiana, at the request of the Royal Colonial Institute, he gave an address on the development of British Guiana—a development which he thought all those interested in the Colony desired to see, and he hoped would be brought about within his lifetime. It was a totally different proposition to build a railway to the Brazilian frontier from what it was to build a railway in any other country in the world, simply because of the scarcity of population. With a huge country of 90,000 square miles, containing a population of only 300,000, largely employed in existing industries, it was obvious that no labour could be spared for the development of the interior of the Colony. The railway should be gradually built with labour from outside the Colony, and in the paper to which he had referred he showed how very desirable it was that an effort should be made to induce immigration into the Colony in the form of colonising families. Two types of settlers were required—people who were prepared to work for wages and people who would colonise the interior, and, as the railway proceeded, take up the various industries which could be best undertaken in family life. The photographs the author had shown of the magnificent savannahs and the Kaieteur Falls and the riches of the interior of British Guiana inspired one with the greatest possible desire to see a practical scheme carried out for opening up the interior. Indians were required for labour in the agricultural industry, and his suggestion was that the colonising families should be obtained from the same sources from which they were obtained in Brazil; but in these days one would be very anxious to see British Guiana populated by British people. That was one of the lessons of the war—we desired to see our own countries populated by our own people, and, therefore, one would think twice before inviting large colonies of aliens to come and settle in British Guiana. The future prosperity of the Colony depended very much upon what the Imperial Government was going to do. The prosperity of British Guiana had been great during the war, and might continue so for some years afterwards; but if that prosperity was going to be built up permanently there must be security for capital and industry. That had never been the case in the past, but it would have to be so in the future. It was easy enough to formulate schemes for the development of new industries, but unless the people who took up those new industries were given some security, they would not come to the Colony in large numbers and make a success of the industries, and so build up the prosperity of the country. Although he had been interested mainly in the sugar industry, he was very anxious to see the other riches of British Guiana developed. That development must be carried out with prudence, and the proper steps must be taken to ensure the success of the industries.

Mr. Edward R. Davson said it was very gratifying to find that the author, having laid down the reins of office, was still sufficiently interested in British Guiana to write such an admirable paper about it, the study of which he was sure would be of great benefit to the Colony. He quite agreed that a railway into the interior would be an excellent thing for opening up the Colony, a railway not so much in the direction of a trans-continental trunk line, as to the advantages of which he was still a little sceptical, but one primarily for the development of the resources of British Guiana itself. There were two points that had to be considered in connection with any railway, or any development of the Colony, whether in the hinterland or on the coast, namely, money and labour. The revenue had been increasing considerably in the last few years, but at the same time the cost of administration had been rising, and there was also the apparently never-ending drain upon the resources of the Colony in the maintenance of its coast defences. It was the great tragedy of the country that a large part of the money collected by taxation was being spent in such a manner that no return could be obtained from it. Even more important than that was the question of labour. It was deplorable that at the present time, when the Mother Country was in need of a great variety of products which could be grown in British Guiana, they could not be cultivated because of the scarcity of labour. Even with regard to rubber there were grave doubts whether, with the present cost of labour, British Guiana could ever compete with the East. If a new industry was started in the Colony it simply drew people away from an old industry. The great problem of the country was the problem of labour; if that could be solved then he believed the development of British Guiana would automatically follow.

Sir Sydney Olivier, K.C.M.G., C.B., in proposing a vote of thanks to the author, said he himself had been connected with the Colonies most of his life, and had passed through that curious experience of a colonial Governor, who, serving in places where obviously very much more might be done both for the Colony itself and for the Empire, thought and schemed to get things done, which seemed so reasonable and in some respects so simple, and yet for lack of ways and means had to see them remain undone. All present would be very grateful to the author for reading the paper, which served to remind them of the existence of places like British Guiana and the West Indies, which he hoped would be much more in the thoughts of the people in this country after the war than they were before. He was rather struck by the passage in the paper where the author spoke of the bauxite industry, which it was apparently considered quite natural should be developed by an

American company. He had lived in Jamaica and had seen a great deal of money made there by Americans instead of British people. British capitalists had been extremely shy of investments in the West Indies and of any kind of progressive work there, because from their experience in the sugar industry they had felt they could not be reasonably sure of making a profit. Speaking as a Free Trader, he thought the British Isles had treated the West Indies very scurvily. It would have been very much better for them at the present time if they had treated the British West Indies in a more just and patriotic manner, because then the sugar production of those colonies, and consequently our own domestic supply, would have been in a much more healthy condition than it was at present. It was most important that those who knew something about the outlying parts of the Empire should attract all the public attention they could to those colonies. Although the photographs the author had shown and the descriptions he had given conveyed an idea of the beauty of British Guiana, no pictures could reproduce the effect of the extraordinary spiritual exaltation one obtained from the early morning aspect of such upland tropical forest scenes as those referred to in the paper. If in time the uplands of British Guiana could be made a resort for Europeans and a place for European colonisation, it would add very greatly to the sum of human happiness, and he thanked the author for having indicated some of the ways in which that could be done.

Mr. W. A. Wolseley, in seconding the resolution, said that as the labour supply of the Colony had been specially referred to, he would like to point out the following fact: the success that had attended the production of sugar in British Guiana, and also of rice, in recent years, had been due in a large measure to the introduction of East Indian immigrants under indenture. Many of these immigrants were not agricultural labourers at all, but were taught and trained to be so during their period of indenture. The result was a body of labourers most efficient and, owing to their own qualities, as pleasing and satisfactory as any employer could desire. He, therefore, greatly regretted that immigration under indenture to British Guiana had ceased.

The resolution was carried unanimously.

Sir Walter Egerton, in reply, said, in reading such a long paper and touching on such contentious subjects, he had been peculiarly fortunate to have evoked such mild criticism. The question of a hinterland railway in British Guiana was a very contentious subject. Naturally the planters on the coast dreaded their labour being attracted to the interior, and he agreed with Mr. Sandbach Parker that when that railway was built it should be built with newly imported labour. He did not think, however, the planters need fear that if the railway was built there would be a sudden rush to the interior. The people who lived in British Guiana had grown accustomed to their semi-amphibious life there, and probably they would not like living on hills. Most of them had never seen a hill; the highest point one drove over from one end of the coast to another was the top of a bridge traversing one of the canals. The railway, however, could be made to pay without population. There were over 10,000 square miles of savannah country in British Guiana ready to carry a hundred times the cattle that were now there, and a trade in cattle would grow up that would be quite sufficient to pay the working expenses of the railway. A railway of that kind, giving access to fertile country, would be a certain attraction to immigrants from outside the Colony who were not accustomed to live half under water at high tide. British Guiana's past prosperity, its present prosperity, and probably its future prosperity for a long time to come, depended on the sugar industry. He agreed with Sir Sydney Olivier that the country had not been well treated in the matter of its sugar production. Surely after the war this country would adopt the policy of the United States and give some sort of preferential treatment to its colonies, and not allow the produce of foreign lands to be brought to this country to the detriment of lands which had been developed with the capital and labour of its own people. Cuba and Honolulu had enjoyed wonderful prosperity through being linked to the United States. Had the granting of preferential treatment to sugar imported from those countries injured the people of the United States? The answer was that they had tried it now for a long time and they still persisted in the policy, although there had been proposals brought forward for its abolition.

Mr. Alan S. Cole, C.B., expressed the thanks of the Council to Sir Everard im Thurn for presiding, and the meeting terminated.

CHICLE INDUSTRY OF GUATEMALA.

The chicle industry of Guatemala is confined almost exclusively to the Peten—that inaccessible north country of the Republic bordering on Mexico and British Honduras. Apart from the archæologists from Harvard and Yale Universities, who find in the ruins of Peten a remote past of increasing interest, Peten remains virtually unknown except to the workers in the chicle and mahogany districts.

The country is reputed to be of dense tropical undergrowth, swampy, the climate very unhealthy, but a territory rich in undeveloped resources. Concessions for constructing a railway in the Peten have been sought from the Government, but none has yet been granted.

It is estimated that the investment in the Peten country in the chicle industry aggregates about £50,000. No one is permitted to gather chicle without a Government concession. Four concessions of this nature have been granted, and they cover the most desirable chicle lands of the region. Good chicle land is said to be worth from £300 to £400 per caballeria of 33⅓ acres, but nearly all the land is owned by the Government of Guatemala, the owners of concessions enjoying only the right to remove the chicle. Chicle grows wild, and steps have never been taken either to cultivate the tree or to provide for reforesting the land with it.

The chicle resources of the Peten country are declared to be practically inexhaustible. It would appear from the statements of concessionaires that no formal estimate of the chicle in the Peten region has been made; and that, in many instances, holders of concessions do not know just what amount of chicle grows on their land. The tree, which bears a luscious brown fruit, is found chiefly at altitudes ranging from 500 to 2,000 feet. In some districts twenty-five to fifty trees are found per acre, while in other regions the trees are greatly scattered.

From a report by the United States Consul at Guatemala City, it appears that chicle trees are boxed and cupped in a manner similar to the "boxing" of pine trees for the extraction of turpentine or resin. A large tree will yield as much as 100 lb. of the crude gum, and smaller and younger trees less in proportion. The trees are boxed on an average three times in as many years. The gum is boiled in large iron pots, from which it is poured into wooden boxes with a capacity of 80 lb. each. The gum hardens in these boxes, and it is carried in this form to the shipping seaport, where the boxes are removed and the chicle packed in sacks for export.

Native labour is employed by the chicle producers, and the workmen are said to be among the highest-paid labourers of the Republic, receiving at the rate of £2 for each quintal of chicle they gather. At this rate, an industrious workman earns from £5 to £6 per month.

Flores is the principal Guatemalan market for assembling chicle; the bulk of the product is shipped for export *viâ* Belize, British Honduras. In Flores crude chicle is worth £3 to £4 per quintal of 101·4 lb. Most of the chicle is carried from Flores by muleback to El Coyo, and thence shipped *viâ* the Belize River to Belize, British Honduras. By the time it reaches the seaboard the chicle has appreciated in value from £6 to £8 per quintal.

Prior to the European war a part of the chicle movement was to England, but at this time practically the entire product goes to the United States, where it meets with a ready market. In the year 1915 a total of 7,238 quintals of chicle, valued at £48,200, was exported *viâ* the frontier custom-house of Peten; for the year 1916 the total chicle exportation was 4,071 quintals, valued at £27,100.

GENERAL NOTES.

British Scientific Products Exhibition.—The British Science Guild is organising a comprehensive exhibition of Products and Appliances of scientific and industrial interest which, prior to the war, were obtained chiefly from enemy countries but are now produced in the United Kingdom. The exhibition, which will be held at King's College from about the first week in August until the first week in September, will show in the first place products chiefly imported from Germany before the war, but now made in this country; but it will also illustrate the remarkable developments that have taken place generally in our scientific industries. In many of these, as a matter of fact, Great Britain always excelled, and it is only our national quality of self-depreciation which has prevented the public from appreciating the fact that we were able to export to Germany apparatus and products embodying the highest scientific knowledge and technical skill. The exhibits will include chemical products, thermal, electrical and optical appliances, glass, quartz, and refractory materials; photographic apparatus and material; surgical and medical appliances; and papers and textile products. It is believed that the effect of the exhibition will be to have a most stimulating influence upon scientific and industrial research; and the exhibits, and the demonstrations and lectures that will be given in order to explain them, will undoubtedly bring home to manufacturers, as well as to the general public, the great and growing part that science plays in industry. Further particulars may be obtained from the Organising Secretary, 82, Victoria Street, London, S.W. 1.

Paraguayan Handmade Lace.—Among the cottage industries of Paraguay is the manufacture of a lace called "nanduti" (from the Guaranian word meaning web). The articles produced, which are all made by hand, include parasol covers, handkerchiefs, doylies, boleros, mantillas, table mats, shawls, edging and insertion. The articles most popular with the foreigners in Paraguay are parasol covers, mantillas, doylies, handkerchiefs and mats, these being made of silk or very fine cotton thread. These laces, reports the United States Consul at Asuncion, appear to be superior in quality and design to similar laces made in the Canary Islands and Mexico. A handkerchief that requires from six to eight weeks to make sells in Asuncion for 100 to 150 Paraguayan pesos, and a parasol cover that takes a year to make sells for 600 to 1200 pesos, the Paraguayan peso at the date of the report being worth about 1½*d*. The lace is usually sold by peddling it from house to house, and, so far as is known, it has never been exported to any important degree. However, the leading export houses in Asuncion might be in a position to handle the trade should a foreign demand for the lace develop.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

MEETINGS FOR THE ENSUING WEEK.

Monday, June 17...Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Rev. Professor D. S. Margoliouth, "The Future of Education."

Brewing, Institute of (London Section), Imperial Hotel, Russell-square, W.C., 6.30 p.m. Mr. A. R. Ling, "The Storage of Hops."

Tuesday, June 18...Statistical Society, 9, Adelphi-terrace, W.C., 5.15 p.m. Mr. K. Yamasaki, "Recent Economic Developments in Japan in their relation to her Trade with the United Kingdom."

Wednesday, June 19...Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Professor E. W. Hope, "The Influence of a Ministry of Health on Local Organisation and Administration."

Meteorological Society, 70, Victoria-street, S.W., 5 p.m. 1. Dr. S. Chapman, "The Lunar Atmospheric Tide at Greenwich, 1854-1917." 2. Mr. M. Christy, "On the Audibility of the Gunfire on the Continent at Chignal St. James, near Chelmsford, during 1917." 3. Mr. F. J. W. Whipple, "Seasonal Variation in the Audibility of Distant Gunfire."

Microscopical Society, 20, Hanover-square, W., 8 p.m. 1. Professor B. Moore, "Photo-synthetic Processes." 2. Dr. E. Penard, "A New Type of Infusorian, Arachnidiopsis paradoxa." 3. Messrs. E. Heron-Allen and A. Earland, "Diatom Ooze from Deep Antarctic Waters." 4. Mr. J. M. Offord, "Exhibition of Gnats and Gnat larvæ."

Geological Society, Burlington House, W., 5.30 p.m.

Thursday, June 20...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4.30 p.m. (Indian Section.) Hon. Sir Dinshaw E. Wacha, "Indian Cotton and the Cotton-Mill Industry."

Linnean Society, Burlington House, W., 5 p.m.

Chemical Society, Burlington House, W., 8 p.m.

Friday, June 21...Chadwick Public Lecture, Mansion House, E.C., 5 p.m. Professor D. W. Thompson, "Our Fisheries and the Food Supply. Lecture I.—The Catch by Line and Trawl."

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FRIDAY, JUNE 14, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

THURSDAY, JUNE 20th, at 4.30 p.m. (Indian Section.) A paper by the HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, on "Indian Cotton and the Cotton-Mill Industry" will be read by SIR CHARLES ARMSTRONG, late Chairman, Bombay Chamber of Commerce. The RIGHT HON. E. S. MONTAGU, M.P., Secretary of State for India, will preside.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Sixty-fourth Annual General Meeting, for the purpose of receiving the Council's report and the Treasurers' Statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new Fellows, will be held, in accordance with the By-Laws, on Wednesday, June 26th, at 4 p.m.

(By order of the Council),

GEORGE KENNETH MENZIES, *Secretary.*

SWINEY PRIZE.

The Council have to give notice that the next award of the Swiney prize will be in January, 1919, the seventy-fifth anniversary of the testator's death. Dr. Swiney died in 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize, on every fifth anniversary of his death, to the author of the best published work on Jurisprudence. The prize is a cup, value £100, and money to the same amount; the award is made jointly by the Royal Society of Arts and the Royal College of Physicians.

In accordance with the arrangement with the Royal College of Physicians, the award next year will be for Medical Jurisprudence.

Any person desiring to submit a work in competition, or to recommend any work for the consideration of the judges, should do so by letter, addressed to the Secretary of the Society.

The following is the list of the recipients:—

1849. J. A. Paris, M.D., and J. Fonblanque, for their work, "Medical Jurisprudence."

1854. Leone Levi, for his work, "The Commercial Law of the World."

1859. Dr. Alfred Swayne Taylor, F.R.S., for his work, "Medical Jurisprudence."

1864. Henry Sumner Maine (afterwards K.C.B.), D.C.L., Member of the Legislative Council of India, for his work, "Ancient Law."

1869. William Augustus Guy, M.D., for his work, "Principles of Forensic Medicine."

1874. The Right Hon. Sir Robert Joseph Phillimore, D.C.L., for his work, "Commentaries on International Law."

1879. Dr. Norman Cheevers, for his work, "Manual of Medical Jurisprudence of India."

1884. Sheldon Amos, M.A., for his work, "A Systematic View of the Science of Jurisprudence."

1889. Dr. Charles Meymott Tidy, F.C.S., for his work, "Legal Medicine."

1894. Thomas Erskine Holland, D.C.L., for his work, "The Elements of Jurisprudence."

1899. Dr. J. Dixon Mann, F.R.C.P., for his work, "Forensic Medicine and Toxicology."

1904. Sir Frederick Pollock, Bart., and Professor F. W. Maitland, for their work, "The History of English Law before Edward the First."

1909. Dr. Charles Mercier, for his work, "Criminal Responsibility."

1914. John W. Salmond, K.C., for his work, "Jurisprudence."

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING.

Wednesday, May 1st, 1918; The RIGHT HON. LORD BALFOUR OF BURLEIGH, K.T., G.C.M.G., G.C.V.O., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Cleminson, H. M., London.
Dutton, Reginald John Garfield, Skegness.
Howell, Alderman Thomas H., Newport, Monmouth.
Librarian, National Library of Ireland (Department of Agriculture and Technical Instruction), Dublin.

Martineau, William, Wallingford.
Oury, Libert, London.
Taylor, W. Howson, West Smethwick.

The following candidates were balloted for and duly elected Fellows of the Society :—

Burley, Sydney Waterlow, Sittingbourne, Kent.
Kendrick, A. F., London.
Lawrey, William, Penzance.
Newman, James Harold, London.
Oliver, William Grant, L.D.S., London.

The paper read was—

SUGAR FROM SEVERAL POINTS OF VIEW.*

By George Martineau, C.B.

Dr. H. C. Prinsen Geerligs, in his fine work on "The World's Cane Sugar Industry, Past and Present," gives a long and interesting account of the early history of sugar. He goes back to Hindu mythology. A certain famous hermit, once upon a time, was desired by an Indian prince to procure for him permission to be translated to heaven during his lifetime. This was refused, but the hermit kindly furnished for him a temporary paradise on earth. This seems to have included, among its many delights, the sugar cane. After the destruction of this paradise, the sugar cane was spread all over the world as a memorial of the famous hermit. No date is mentioned.

When we emerge from these pre-historic times we again meet with real sugar, for the first time, in India. It is called "gur" in India now, and that seems to have been its name from very early days.

In the seventh century, A.D., the fact is on record that a Chinese Emperor sent people to India to learn the art of sugar manufacture. The natives in India at the present time are content to produce "gur" by boiling down the juice from the cane till it solidifies. But it appears that even in that early period the Arabs, when they got hold of the sugar cane, learned to purify the raw sugar by re-crystallisation and to produce a great variety of sweetmeats.

In the thirteenth century travellers reported the existence of many sugar factories in China. Then we hear of the Arabs taking the sugar cane to Sicily, and thence to Africa. Thus it spread all round the coasts and islands of the Mediterranean. The Crusaders found extensive sugar plantations in many parts. Spain boasted of a flourishing sugar industry even in the twelfth century. From China the sugar cane found its way to the Indian Ocean, to Siam, the Philippines, Formosa, and Japan. But in those days it was only in China and the countries round the Mediterranean that a real sugar industry existed. The Crusaders took a great interest in the cultivation of the sugar cane, and founded many important centres of the industry.

When these early industries produced more than they consumed, a trade in sugar sprang up. The Crusaders, when they got home, began to import it, and a brisk trade started between the Italian ports and Northern Europe. It is curious to note that in these early days the traffic was in refined, not raw sugar. This is easily explained by the fact that the art of sugar-refining had not yet reached to Northern Europe. It was actually loaf sugar that the Crusaders and others imported from the Mediterranean ports. We hear of Damascus and Tripoli becoming great sugar-refining centres in the fourteenth century.

Then, alas! in the fifteenth century the Turks began to overrun these countries, and the sugar industry had a bad time; in fact, as Dr. Prinsen Geerligs says, "the once flourishing sugar industry of the Mediterranean was condemned to extinction." But, in the meantime, the Portuguese took the sugar cane to Madeira, the Azores, the Cape de Verde Islands, and the Gulf of Guinea. Spain colonised the Canary Islands. In all these places a new sugar industry spran up and flourished, especially with the help of slave labour. Then came America. Spain, Portugal, Holland, Great Britain and France colonised a vast territory, and sugar, instead of being a fancy luxury, soon became an article of common consumption. Fertile land, a favourable climate, and cheap labour formed the basis of the great sugar industries of the West. First Brazil, then the West India Islands, English, French, Spanish, and Dutch, then other countries on the mainland of America, Surinam, Demerara, Berbice, and finally Peru, Argentina, Chile, Mexico, and Louisiana. The competition

* This paper is written to prove, from the history of sugar during the last sixty years :—

1. That nascent industries can be encouraged, research stimulated, and efficiency created, by a rational, well regulated, but moderate stimulus.

2. That preferential treatment in home markets is the best, perhaps the only, way to give real confidence to capital; and that with that confidence, coupled, of course, with favourable natural conditions, British industries will flourish, and may even become capable of furnishing the whole consumption of the Empire.

3. That the dumping of commodities below cost price is a fatal injury to the consumer.

from these new countries soon extinguished the little industry in Madeira, the Cape de Verde, and the Canary Isles.

France introduced sugar cane into Mauritius and Réunion, which soon began to export sugar to Europe. Early in the eighteenth century the Dutch East India Company, which had been importing sugar from Formosa, Bengal, and Siam, introduced the sugar cane into their Island of Java; but the wonderful success of that most remarkable of all cane-sugar industries did not take place till long afterwards.

Then, at the birth of the nineteenth century, came the great war between France and Great Britain, and the cane-sugar industry had a bad time. Naval engagements in West Indian waters, the sinking of sugar cargoes, the capture of merchant ships, not only from the West but also from the East, and other blows dealt by France at British trade, did not conduce to the development of the cane-sugar industry. Finally came Napoleon's "continental system."

I am much obliged to Dr. Prinsen Geerligs for enabling me to give this brief sketch of the early history of cane sugar, and can now go forward to my own personal experiences from 1856 to the present day.

In 1856 our industry of sugar-refining was in a flourishing state. Practically all the loaf sugar consumed in this country was produced in the East End of London, where about twenty refineries, each doing a few hundred tons a week, were very busy, giving work and wages to the surrounding neighbourhood, and keeping the London Docks fully occupied with the thousands of hogsheads of West India sugar which were annually imported. That was the sugar which we principally used, helped out with sugar from Mauritius, British India, the foreign West Indies, and the foreign East Indies. The total, in 1856, was 384,000 tons of raw cane sugar, to which must be added 9,000 tons of foreign refined sugar and 4,000 tons of raw beetroot sugar. That gives a total consumption of 397,000 tons. The remarkable point is that of the 384,000 tons of raw cane sugar 285,000 tons, 70 per cent., came from our sugar-producing British Possessions, East and West, but especially West. Those were good days, not only for British sugar-refining but also for the British West Indian Colonies and Mauritius. It will be interesting, for a moment, to look at the kind of sugar which the world produced in those days, and especially at our largest contributors, the British West Indies.

The British West Indian sugar of sixty years ago was an excellent class of raw sugar, so good, in fact, that a considerable portion of it was pure enough to go direct into consumption, and it is with regret that those who were intimately acquainted with it view its impending abolition. It was well made, with great skill and care, a skill which has probably by this time nearly died out. It was a primitive process, but much superior to other primitive processes of those days, some of which, unfortunately, still survive. It was called "muscovado sugar," and was produced by a simple process, giving a good result when well done, but very different to present requirements.

At the date with which we are now dealing the world produced about 1,200,000 tons of cane sugar and 250,000 tons of European beetroot sugar—total 1,450,000 tons. The cane-sugar producing countries of those days, mentioned in the order of their importance, were Cuba, Java, Mauritius, the British West Indies (including British Guiana), Brazil, Porto Rico, Manilla (the name in those days for sugar from the Philippine Islands), Réunion, Louisiana, and the French West Indian Islands of Martinique and Guadaloupe. The finest raw sugar came from Java, Mauritius, the French West Indies, Réunion, and Louisiana. Cuba made a semi-refined raw sugar called Havana, but the bulk of its production was a muscovado sugar, very inferior to the British variety. Porto Rico, on the contrary, produced a very fine muscovado sugar, quite fit for direct consumption. The sugars from Brazil, Manilla, and British India, were very low brown impure varieties, requiring a great deal of refining. The British refiners were experts with that class of sugar, while the foreign refiners, in France and Holland, preferred the easier work —mere child's play—with a raw material of a much higher grade, in fact, almost pure.

The British sugar-refining industry in 1856 was not confined to London, though London produced practically the whole of the loaf sugar which we consumed. Bristol was a very old-established centre of the industry. The great house of Finzel, then the largest refinery in the country, was celebrated for its large grained crystallised sugar, and was the first to use the newly invented centrifugal machine. Liverpool also was a large contributor to our refined-sugar production. Ships from Brazil were constantly arriving in the Mersey and bringing, among other things, the low brown sugar from that country. In the Clyde also a new and flourishing

industry of sugar-refining was springing up. It increased with great rapidity, having discovered a new way of producing yellow sugar of very superior colour and quality, a kind popular with the buyers of the cheapest article. The history of the rise and progress of this industry is interesting, as an indication of the vicissitudes through which the sugar-refining industry of this country had to pass between 1887 and 1903.

In 1854 the sugar-refiners of Greenock (and Glasgow) imported 50,000 tons of raw sugar. In 1865 they imported 136,000 tons, and the figure went on increasing rapidly until, for the five years, 1877–81, the average yearly importation was 248,429 tons. This figure held till 1887, when a fall, as rapid as the rise, set in. For the five years, 1887–91, the average yearly imports had fallen to 228,733 tons, for the following five years to 170,373 tons, and for the years, 1897–1900, to 124,874 tons, a lower figure than that from which they started in 1865. Presently we shall see the reason why.

This is the completion of our brief sketch of sugar sixty years ago. Let us turn to another picture—after a violent revolution. The last year of the nineteenth century, 1900, was a record year in the history of sugar. Our consumption had risen from 397,000 tons to 1,624,000 tons—more than four times as much. That is a wonderful fact, but another, far more incredible, comes next, namely, that out of this enormous quantity of sugar consumed in the United Kingdom only a little scrap, 129,000 tons, was produced from the good old sugar cane. Even that small quantity would not have come to us had it not been for two facts—first, that our Colony of Demerara produced a very choice kind of yellow crystallised sugar which a few intelligent connoisseurs insisted upon having; and, secondly, because two of our sugar-refining firms stuck to cane sugar, hoping to obtain a fancy price for their refined sugar. We hope they did.

But there is one more almost equally incredible fact to be revealed. The world's production (not including the imaginary figure for British India, which now confuses our statistics) had increased from 1,450,000 tons to 8,291,800 tons—nearly six times as much. Now comes the most wonderful fact of all. Of this quantity, only 2,880,900 tons was the product of the sugar cane—less than 35 per cent.; in other words, nearly two-thirds of the world's production of sugar came from the beetroot fields of Northern Europe and, to a small extent, from the beetroot fields of the United States. These facts are worth looking into, in order to discover causes for such startling effects. I could spend several hours in explanation—all of it interesting—but we must be brief.

There is no need to go into the history of the origin of beetroot sugar here; suffice it to say that Napoleon Bonaparte had something to do with it, and also the King of Prussia. I said that in 1856 Europe produced about 250,000 tons of beetroot sugar. That was doubled in ten years, and in five years more the production exceeded a million tons. Another ten years raised the figure to two millions. This brought cane and beet neck and neck in the race; then beetroot shot ahead to three, four, five, and six million tons.

There are two causes at the bottom of this mystery. Energy, ability, efficiency, and, more than all, persistent research, constituted the first and best cause. But this best cause is not to be had, as a rule, unless you give it a stimulus. Capitalists do not care to risk their money unless they can see very clearly that there is some security for their investment. That is exactly what the European beetroot-sugar industry enjoyed; all except France, who had to languish till 1884. France gave the research most liberally, but she lacked the stimulus.

It was Germany that hit upon the right kind of stimulus. It was a brilliant idea, quite an inspiration, and was carried out with great judgment. The sugar duty was levied—not upon the sugar produced, but upon the roots. This at once stimulated the farmer to produce the richest possible quality of root, and the manufacturer to extract from the root the largest possible quantity of sugar. Great pains were taken to breed an improved variety of sugar-beet. This great research lasted for years, and still goes on. Its success was astounding—incredible. At the beginning the sugar-beet contained less than 6 per cent. of sugar. In France it continued to contain less than 6 per cent. of sugar until the stimulus was applied in 1884 to save the life of the industry. But in Germany the roots went on, year after year, increasing in richness until, in 1908, the average quantity of sugar actually extracted from the roots for the whole of Germany was 17·63 per cent. I used the word "incredible," and it is the only word to use. The natural quantity of sugar contained in the sugar-beet had been multiplied by three. For the ten years, 1899–1908, the average yield for the whole of Germany

was 15·49 per cent. This shows what can be done by giving a rational and very moderate stimulus. That this wonderful result was caused by the stimulus—plus, of course, great efficiency—is proved by the lamentable fact that poor France, who received no stimulus till 1884, was at that date getting a yield of less than 6 per cent. of sugar, while Germany at the same time was producing 11 per cent. of sugar from the roots as the average for the whole country. France hastened to adopt the German system, but never succeeded in catching it up in the race. The average yield for the ten years, 1899–1908, which, as I have said, was 15·49 per cent. for Germany, was only 12·84 per cent. for France. This is the worst of being "too late." In industry it is fatal. Austria, with a system similar to that of Germany, got a yield of over 15 per cent. for those ten years.

Research was still rampant, and the breeding of the rich roots led to the invention of the diffusion process—another result of the stimulus. This process, now brought to great perfection, practically extracts the whole of the juice, and in a very pure state. In my book on sugar I gave the results of a good German factory in 1908, from which it will be seen that the average quantity of sugar contained in the roots worked by that factory throughout the season was 17·10 per cent., and that the quantity actually extracted was 16·64 per cent. These figures show what can be done when efficiency reigns supreme, and they are also a good illustration of the perfection to which chemical control of a sugar factory can be brought. Everything that happens is known, down to the second place in decimals. France, so long as she worked roots containing less than 6 per cent. of sugar, could not attempt the diffusion process.

Another instance of the valuable results of research is the multiple evaporator, called by the French the "Triple Effet." The French had a considerable share in bringing this invention to a practical success. It has enabled the sugar factory to perform the most important and expensive part of its process—that of evaporating the thin juice till it is thick enough to crystallise in the vacuum pan—with the lowest possible expenditure of fuel. Research is still going on with regard to this part of the process, and has not yet said its last word.

Greatest of all the results was the gradual development of the new method of purifying the juice, called the double carbonatation process. We have no time, on such an occasion as this, to describe processes, but I can safely assert that this must be regarded as one of the greatest of all the results of the researches of the last fifty years in the world of beetroot sugar. It has now found its way to Java, where fine white sugar is being produced in large quantities by means of it. But here again there is no finality, and it is quite possible that a still better process, giving equally good results at less expense and trouble, may eventually take its place. Research is still busy with it.

The great cane-sugar industries of the world did not take a *laissez-faire* view of the subject. They immediately buckled to and set their house in order. They at once adopted the multiple evaporator, and now every modern factory has one, or perhaps several. The diffusion process was tried, but found to have too many drawbacks when applied to cane-sugar production; but they were determined to try to extract if possible nearly the whole of the juice in the cane. Instead of having only one three-roller mill, which squeezes the cane twice, they now have four, placed tandem fashion with travelling bands between, and thus give the cane eight squeezes. They also place two rollers with rough surfaces at the entrance to the first mill, which crack the hard crust of the cane before it enters the mill. With these improvements and "maceration" of the "megass" (the crushed cane) in its transit from mill to mill, they now extract 95 per cent. of the juice, and are ready to fight the beetroot industry. Instead of hundreds of tons, they are turning out thousands from each factory, and thus reducing cost of production. They have, however, their own special difficulties to surmount. Labour is one of the greatest. Here Java is in a favoured position. She has also good soil and climate, great efficiency in management, and a fairly good system of irrigation. The necessity of supplying the cane with sufficient water is vital, and water is not always attainable.

The cost of production depends, to a great extent, on the quantity of canes per acre which can be produced. Java produces more than forty tons as an average for the whole of the island, and can therefore produce sugar at a very low cost, all the factory arrangements being thoroughly efficient. Half of Java's crop of about 1,500,000 tons (rapidly increasing) is now produced in the form of white granulated sugar of high quality, which goes to British India for the benefit of the upper classes. Our Colony

of Mauritius is doing the same, and deserves to succeed after all the cruel troubles she has gone through. White sugar direct from the beetroot juice has been produced for a long time. The present writer recollects seeing one beetroot factory in Germany, as long ago as 1871, turning out good loaf sugar; and at a later date he saw Eugen Langen, the inventor of the cube-sugar process, producing very fine cubes at his factory at Elsdorf direct from the beetroot juice.

This great effort of the cane-sugar industry to compete with beetroot brings us to another striking result of giving industry a stimulus. I have shown how the German stimulus, rationally applied, led to greater efficiency, profound research, and most astounding results. I have compared it with the sadly backward state of the same industry in France, so long as it received no stimulus. And yet I find, if I consult a recent utterance of the *Council* of the Manchester Chamber of Commerce, that industries receiving such a stimulus are bound to become "apathetic and inefficient." Very well, I have given facts of practical experience in flat contradiction to this doctrine—a doctrine, by the way, which the members, as distinguished from the Council, of the Manchester Chamber have now, I am glad to see, repudiated most emphatically.

I will now give more facts of practical experience, this time from the cane-sugar industry, which again will prove conclusively that this doctrine, so glibly repeated as if it were an axiom, is an absolute delusion. The United States of America give preferential treatment in their own markets to sugar produced in their own states, territories, and dependencies. They also gave a slight preference—rather more than half a farthing a pound—to their *protégé*, Cuba. Let us see what has been the result of this preference—absolutely inappreciable to the consumer. Cuba, before the Spanish-American War, just succeeded in producing a million tons of sugar per annum in the years 1894 and 1895. After the American occupation in 1898, and when the unfortunate industry had succeeded in recovering from the devastation of the war, the stimulus of the small preference began to tell. In 1903 Cuba got back to the million ton figure. In 1913 it produced 2,500,000 tons, and last year it would have produced 3,500,000 tons, but, unfortunately, when the sugar was badly wanted, an insurrection broke out in the eastern part of the island, and the actual production was reduced to 3,000,000 tons. This enormous increase was the result of the security capitalists found in the small American preference. Large factories were erected, railways connecting them with the shipping ports were constructed, everything was done in the most up-to-date style, and the only trouble was to get the sugar sold and shipped as soon as possible. The United States markets were glutted during the thickest part of the crop time, and prices went down sometimes more than £2 per ton below the European level. The American consumer actually gained by the preference.

In Cuba at the present time there are many factories that turn out from 10,000 to 20,000 tons of sugar per annum. There are about the same number which turn out from 20,000 to 40,000 tons. There are eight that turn out from 40,000 to 60,000 tons. There are three that turn out from 60,000 to 80,000 tons. There is one that produces between 80,000 and 100,000 tons, and there is one that produces more than 100,000 tons per annum. This is the "apathy and inefficiency" created by giving a preference!

The greatest research now going on in the cane-sugar industry is the breeding of new varieties of cane which shall give more sugar, resist disease, and be suitable for various soils and climates.

I will conclude by giving one more instance of the results of preferential treatment in the home market. We know from recent experience how comfortable it would be if we could produce enough sugar for our own consumption without going to foreign countries for it. The United States are now in that happy position. Since the preference was granted Louisiana has increased her production from 95,000 to 414,000 tons; domestic beetroot from 1,000 to 779,000 tons; Hawaii (the Sandwich Islands) from 12,000 to 602,000 tons; Porto Rico from 50,000 to 400,000 tons; the Philippine Islands from 92,000 to 300,000 tons; and, finally, Cuba from 1,000,000 to 3,500,000 tons. If America had not created this great increase in production by giving a preference to her own family and friends we should at the present moment be suffering—and so would America—from a real sugar famine. Instead of that what do we see when we turn to American statistics for 1915? In that year the consumption of sugar in the United States amounted to the large figure of 4,257,713 tons, every ounce of which, with the purely accidental exception of 23,000 tons, came from her own states, territories and protectorates. This striking fact is entirely the result of giving a

preference. The United States, so far as sugar is concerned, is now independent of the outside world, and is even able to spare us a million tons from Cuba whenever we are short of supplies.

This ends my essay. There is another essay that might be written from the opposite point of view, showing the injury done to our sugar industries by competitors armed with an artificial stimulus. I have dealt with that, and with the economic questions connected with it, in a little book entitled "A Short History of Sugar, 1856-1916, a Warning," to which I desire to refer my present audience. But as I made a passing reference to the injury done to our refining industry, as illustrated by the serious reduction in the industry on the Clyde from 240,000 tons per annum in 1882-86 to 125,000 tons in 1897-1910, it is necessary to point out that the cause of this collapse was the enormous importation of foreign refined beetroot sugar, at prices with which the unstimulated producer could not compete. For many years nearly a million tons were imported every year, the sugar being landed at every little port around our coasts. The Brussels Convention came into force in 1903, and the Clyde industry, which can work as cheaply as any refining industry in the world, revived. In 1918, the last year before the war, the Clyde refiners melted 231,333 tons, nearly as much as at the height of their remarkable prosperity in 1877-1886.

A distinguished—shall I say economist?—has recently proclaimed that "the millions should not be deprived of cheap sugar even if it be dumped." To this most attractive exclamation there are three most conclusive contradictions, founded on facts derived from the history of sugar during the last forty years. Those facts prove—first, that the fleeting pleasure of buying a commodity below cost price is disastrous to the consumer, because it is bound to be followed by reduced production and higher prices. Secondly, that under such circumstances the stimulated industry again takes the lead, increases its production, forces down prices once more, and gets one step further on the road to monopoly. That is exactly what happened with sugar. Thirdly, it is a fact that the millions have never been deprived of cheap sugar, except when there happened to be a bad beetroot crop, which is a periodical occurrence. Then prices go up. The dumped sugar, in which the consumer revelled, has made him more and more dependent on the beetroot crop for his supply; when that fails he has to pay the penalty. Then the war broke out, away went the whole of his dumped supply—and now, he is on rations.

These are the conclusive answers to this profound economist. He should begin by trying to master the rudiments of his subject.

[In the absence of Mr. George Martineau, C.B., the paper was read by Mr. Edward R. Davson, President of the Associated West Indian Chambers of Commerce.]

DISCUSSION.

The Chairman (The Right Hon. Lord Balfour of Burleigh, K.T., G.C.M.G., G.C.V.O.) thought all those present must have been greatly gratified by the paper which they had just heard, and would regret that Mr. Martineau was not present to appreciate personally the welcome which his paper had received. There were echoes in the paper of former controversies: it was not necessary to go back so far as the time of the Crusaders to find serious conflicts taking place over some of the points mentioned by the author. The reference to naval engagements and the sinking of sugar cargoes in the past was significant in view of what was taking place in that way at the present time. He had received a certain amount of elementary education in the subject of sugar from having been Chairman of the Commission that went to the West Indies some nine or ten years ago to arrange the preference between Canada and our West Indian Colonies, which he was glad to say had been successful, and was in operation at the present time. He had had a further education in the matter by having been Chairman of the Committee of Commercial and Industrial Policy after the War, whose report had been mentioned in the press during the last few days. He desired to urge that, in spite of the different views held on the subject, every one should as far as possible avoid the fiscal controversies which raged some eight or ten years ago. Consideration should be given to the question of whether any particular article was essential to our national well-being, and important, not only as a raw material for industries, but as an article for consumption by the population of this country. Attention should be given, in the second place, to the natural source of its supply; and, thirdly, to the risk of the supply being disturbed. The safety and security of our Empire and its population should be put first, and abstract principles should, to a large extent, take a back seat. In abstract principle he had always been a member of the Free Trade school, but he held that abstract principles, while they were extremely good servants, were very bad masters. Therefore practical and not theoretical conditions should rule the policy of this country. It was perfectly true that the capitalist must have some

security for the investment of his money if he was to produce articles for general consumption, and the paper showed how successful the German policy with regard to sugar had been. Due attention should be paid to the statement made by the Manchester Chambers of Commerce that "industries receiving such a stimulus are bound to become apathetic and inefficient"; but he thought it was going too far to argue that, because there was a risk that industries receiving preference might become apathetic and inefficient, no preference should ever be given. That amount of security ought to be given to the capitalist which would justify him in investing his money, but would not go so far as to give him a premium upon idleness and apathy and inefficiency. So far as sugar was concerned, at the commencement of the war and during the ten years previous to that date, this country derived a very large proportion of its sugar supply from enemy countries, and the point to be considered to-day was what this country could get from its own Imperial resources without taking a course which, on the one hand, would unduly raise prices, and, on the other hand, would set a premium upon idleness and apathy. The places within the Empire in which the cultivation of sugar was possible must be discovered, and attention must also be given to the question of the cost of carrying on that cultivation efficiently, and to the subject of the freights which had to be paid to bring the article to this country. Freights were in a state of great disturbance at the present time, and it was to be hoped that after the war they would be reduced to a large extent to their pre-war condition. This country must develop its own Imperial resources because, while he most earnestly hoped we should never be at variance either with the United States or with Holland, it was possible that the Ally or the Neutral of to-day might have different interests from ours in the future. If the resources of the Empire were to be developed a certain reasonable continuing security must be given for a period long enough to encourage the investor to put his money into the industry. He did not think it was impossible for this country to do with cane sugar what the Germans did with beetroot sugar, because in all probability the one was as susceptible of improvement on the right lines as the other. This country must pay greater attention to the interests and possibilities of its fellow-subjects in the Empire than it had ever done in the past. If that was done with a real desire to obtain a successful result he thought there was every prospect of success being achieved.

Sir Edward Rosling said he had listened to the paper with very great interest. Personally he was interested in the sugar industry in the very small and much-neglected colony of Mauritius. As a result of bounty-fed sugar, Mauritius for years was on the borders of bankruptcy, and it was only after the Convention that it was able to make a living at all. If after the war the market was again swamped with foreign and bounty-fed sugar, Mauritius would go back to the position it occupied in the past. He did not think protection would make the planters more or less inefficient, because the competition was too great, and even with protection they would have to do their best in order to make a living at all. It was only by organisation and help from the governing powers that the sugar industry of the Empire could be put on a thoroughly satisfactory footing.

Mr. C. Sandbach Parker, C.B.E., agreed with the Chairman that at the present time the people of this country must not allow themselves to be overruled by any fiscal views they might previously have held. They must consider the position as they found it to-day, and as they knew it would exist after the war. The Empire had to decide whether it was going to grow its own sugar or continue to buy it from foreign countries. He did not think any advantage would be gained by this Empire transferring its dependence from enemy countries to other foreign countries. The description given in the paper showed the wonderful results that had been obtained by America in her determination to provide herself with her own sugar supply. Some twenty-seven years ago America tried a system of free importation of sugar for about three years, but they very soon saw the mistake they were making. They realised that they were paying an enormous amount to Germany and to other countries in wages which they could perfectly well pay to their own people, and that they were at the mercy of those foreign countries for their sugar supply. They then reversed their policy, and set to work to build up their own industry by giving the preference to Cuba to which the Chairman had alluded, and by encouraging production in their own territory by giving freedom from Customs duties. The magnificent result obtained by that policy was the most conclusive answer to those theorists who said that preference promoted inefficiency. Except in those parts of the Empire which had a market at their own doors, such as Australia, South Africa, and possibly India, the sugar industry of the Empire had been deliberately stifled by the policy of this country, pursued now for about fifty years, in the belief that it benefited her people to have the cheapest supply of sugar, regardless of whether it was foreign or British grown. If, in 1870, the Government had offered the same inducements to the sugar-growers in the British Empire to improve their industry that were offered in Germany, this country would have been in a very much better position in that respect at the present time. It was commonly believed that during the war the sugar-growing colonies had made enormous profits. It was perfectly true that the price of sugar had been very high, but it was also true that everybody interested in the sugar industry had had to contribute to the cost of the war by means of the excess profits tax. During the war foreign countries, especially Cuba, had been able to gain

the whole of the enormous price to which sugar had been driven by the fact that this country had been dependent on enemy countries for its sugar supply, and during the war had been obliged to buy from other countries which were not supplying it before the war. Cuba had utilised its advantage to set its industry in the most magnificent order, and there was hardly an out-of-date factory in Cuba to-day. After the war this country would have to raise at least £700,000,000 a year of revenue as against £200,000,000 before the war, and all the industries of the country would be handicapped in two ways—(1) by having that millstone round their necks and (2) by having to compete against industries in those countries which during the war had been reaping the full benefit of war prices without having had to pay any part of the cost of the war. It was absolutely essential that any preference now given to the sugar industry should be adequate to produce the results that were required. The Empire was short of 2,000,000 tons at the present time, and if that supply was to be provided within the Empire within a reasonable time, adequate inducements must be given to the capitalist and to labour. It was no use starting with a very small preference, which might possibly promote inefficiency. It was very important to the sugar-using industries of this country to have a supply under British control. Before the war they had been relying on artificially stimulated supplies from Germany and other countries, and were now afraid that in future they would have to pay a great deal more for their sugar. He therefore wished to point out that an adequate preference would bring about an increase in the production of sugar in the British Empire, and, by increasing the world's supply, would reduce the cost of sugar to the sugar-using industries of this country. It would also give them a stable supply, well distributed over the Empire, and not liable to the tremendous fluctuations which resulted from being dependent on one particular part of the world. He was sure it would give the greatest possible pleasure to Mr. Martineau, if, as the result of the report of the Committee on Commercial and Industrial Policy after the war, the Government could be induced to adopt the views expressed in that report, and also the views expressed by the Chairman on the present occasion.

Mr. John R. Drake agreed with the author that the policy of the Government in connection with sugar had been absolutely murderous with regard to the sugar-producing efficiency of the Empire. At one time, taking the ordinary price of sugar as being roughly £10 a ton, the Continent was giving between £3 and £4 a ton bounty—that was to say, 30 or 40 per cent.—with the result that the price of sugar coming into this country from the Continent was reduced to £6 a ton. Our colonies naturally could not compete against that. Having been in business in Germany for many years, he believed that the German policy had been adopted by the German producer and the German Government with the deliberate intention of murdering the British industry in sugar, and also as much as possible the sugar industries of other competing countries. Like the Chairman, he was theoretically a Free Trader. By Free Trade he meant that each country should have the right and power to develop itself on its natural lines; but our colonies had been prevented from developing themselves in that way by the deliberate attacks of the German nation and the German sugar industry. Scientists and capitalists could not be expected to do their best against a Government attack such as he had described. A reasonable amount of help given to our industries would not make them apathetic and inefficient; it was the hopeless position they were in which had in some cases perhaps made them rather inefficient. He agreed with the Chairman that the amount of protection given should be such that it would not improperly raise the price of sugar to the working-classes of this country and should not be such as to create inefficiency and idleness. He believed that the protection afforded should be reasonably limited, and he thought that was also the Chairman's view. He did not agree with Mr. Sandbach Parker that it was possible for this country to obtain all its sugar supply from within the Empire, and surely it was impossible to imagine such a fiscal system being introduced as would prevent there being a certain amount of interchange of articles between ourselves and other countries, and one of the things that, within reasonable limits, we might expect to import would be sugar. Taking into consideration the fact that the sugar industry of the British Empire was to a large extent an infant industry, and therefore deserving of help, he quite agreed that such help should be given to it by the Government as would enable it to fight the preferences given by other countries.

Mr. P. C. Lyon thought the paper preached a moral which was not altogether political, and that the author had shown that, to a very great extent in the history of the sugar industry, science had come into its own. The state of scientific research in this country was not of the happiest description even now, although a great improvement had taken place during the last few years. Private firms engaged in the sugar industry had worked very hard to carry out research, but it still remained a fact that a great deal of research, both in the sugar and other industries, was done by overworked professors at universities. When the Germans took the matter up they paid their men adequately, and they engaged a number of scientists to deal with the question of beetroot sugar, with the result that very large firms were established, providing so great an amount of beetroot sugar that the very difficult scientific problems of making every possible use of the by-products of sugar could be dealt with. Germany went even further than the United States or France—first, in the extraction of the sugar from the pure juice of the

beetroot, then in the further extraction of sugar from the molasses, and finally in the production of valuable chemical products from the residue that was left after every single particle of sugar had been extracted. There was a great deal to be done in fundamental research which could not be undertaken by private firms, but could only be carried out by the industry by means of co-operation on a large scale. It was an encouraging matter that a move had been made by the Empire Producers' Organisation and by a committee appointed by that organisation for the establishment of co-operation in research on a large scale. A good deal had been done in the West Indies and in India by scattered investigators on the agricultural side of growing the cane, but Agricultural Departments were starved all over the world, and the stimulus which the industry could give the Government was required to get better and further work done. If politicians took the matter up, they would be in a far better position to meet the arguments of those who opposed them if they were perfectly certain that the firms engaged in the industry were doing all they could, individually and collectively, from the scientific point of view.

Monsieur L. Soucher said that the paper dealt chiefly with the sugar cane, but he thought there were immense possibilities of sugar production in England, which certainly should enable this country to avoid importing sugar at least from enemy countries. It was extraordinary that the efforts which had been made in England to increase the food production always lost sight of the fact that one of the most important factors to increase the yield of wheat and corn was the cultivation of beetroot. On the Continent, in a good many instances, no profits had been made on the actual cultivation of the beet itself, but it was being cultivated because it brought enormous advantages to the following crops. He believed that in England a very large quantity of sugar could be produced from the cultivation of the beetroot to supplement the sugar which the Colonies produced, and that this country could thus be enabled entirely to avoid enemy producers.

Mr. R. Rutherford (Chairman, West Indian Committee) was glad to find that, although the Chairman and Mr. Drake both expressed the view that they were Free Traders, they qualified their Free Trade. He had always thought that the essence of Free Trade was the survival of the fittest, but that had certainly not been the case with regard to sugar. In his opinion cane sugar was the fittest, but it had not had that opportunity of surviving. He thought Mr. Drake, in saying that he did not believe this country could obtain all the sugar it required from within the Empire, forgot that that was entirely due to the fact that the cane-sugar industry of the Empire had been strangled.

Sir Herbert Matthews said he was chiefly interested in the sugar-beet industry in this country, and believed that there ought to be a great future for that industry. The cultivation of the beetroot would not be displacing other articles of food, but would in its by-products furnish a very valuable and badly-needed cattle food, and would improve and increase the following crops. There were, however, one or two passages in the paper which made him hesitate at the moment to encourage a very large outlay on the introduction of that industry, because the author pointed out the probability of a very large increase in the cane-sugar industry of our Colonies and Dominions. If that increase took place, unless some assistance of a fiscal character could be obtained from the Government, he felt rather nervous as to the future of the sugar-beet industry in this country, which was an infant industry, and would have to go through all the struggles of a new industry. Assistance was needed from the Government for a sufficiently long period to encourage investors to put capital into the industry, which he was confident would be a paying concern to the capitalist and of the greatest help to food production in this country.

Mr. William Martineau said the author emphasised the importance of research as applied to sugar, and personally he was taking part in that research. The British Empire Producers' Organisation had founded an Empire Sugar Research Association, of which he was the honorary secretary. The Association had the support of every sugar-producing colony in the Empire, and of practically every sugar-using industry in England, and was working in close touch with the Government Research Committee. He hoped the efforts of the Association would be of some assistance in reinstating the sugar industry in the British Empire.

Mr. S. Barnett wished to point out that in a period of fourteen years the production of sugar in the United States, in the colonies of the United States, and in Cuba, to which a preference was given, increased by no less than 3½ million tons, the increase in Cuba alone being practically 2½ million tons. If the United States had not adopted the policy of preference twenty years ago, this country would now have practically no sugar at all, and he thought the British Government ought to adopt a similar policy, and should think rather more of the producer and less of the consumer. If a substantial world-wide increase took place in the production of sugar, however, the probability was that the consumer would not have to pay more.

Mr. C. Sandbach Parker said that, with regard to the possibility of the Empire producing within a reasonable time all its requirements in the matter of sugar, to do that the stimulus must be

adequate. Mr. Drake had stated that he believed in every country producing what it was naturally best fitted to produce, and Mr. Rutherford was quite right when he said that the British countries best fitted for the production of sugar had been strangled and driven out of the market. Mr. Drake had urged that any preference given should be small, in the interests of consumers. He, on the contrary, felt that the consumers' interest would be best served by securing a cheap and well-distributed supply, which would be most quickly attained by giving adequate security for the rapid development of the industry within the British Empire.

Mr. Edward R. Davson said he was very glad to have had the pleasure of reading the paper with Lord Balfour in the chair, and desired to pay a tribute to him for all that he had done for the sugar industry.

On the proposition of the Chairman, a hearty vote of thanks was passed to Mr. Martineau for his interesting paper, and to Mr. Davson for reading the paper, and the meeting terminated.

PRODUCTION OF PERILLA OIL AND OIL PAWLOWNIA IN JAPAN.

Dealers in Yokohama estimate that the average annual crop of perilla seed in Japan is approximately 1,000,000 kin (1,330,000 lb.). According to statistics of the Japanese Department of Commerce and Agriculture, 1,283,662 United States gallons of perilla oil, worth £144,000, and 930,436 gallons, valued at £101,000, were produced in Japan in 1912 and 1913 respectively, the latest years for which statistics have been compiled.

An oil used in Japan in the manufacture of oil-paper and paints, and for illuminating purposes, is obtained from the fruit of a tree known under various names in Japan, but scientifically called "abura-giri" ("oil pawlownia") by Japanese, and *Aleuritis cordata* by European botanists. This tree grows wild in Japan, and only five years ago it was for the first time, on a very small scale, cultivated for commercial purposes.

The regions where most of these trees are to be found are on the coast of the Japan Sea, on the main island of Japan. Trees growing on slopes facing the sea and exposed to sea winds produce the best nuts, or those containing the most oil. One that grows wild requires ten years before it bears its first crop of nuts. By fertilising, a tree may be made to bear fruit four years after it is planted.

The use of the "oil pawlownia" product has been known in Japan for a long time, but, according to a report by the United States Vice-Consul at Yokohama, has not yet acquired any commercial importance. The oil is extracted by the most primitive methods (drying, pounding, steaming, and crushing) by producers on their farms. Japan's output is about 1,500,000 bushels of nuts annually, from which 238,300 gallons of oil are obtained. None of this oil is exported from Japan. Shells and kernels crushed together give 36·1 per cent. of oil, while 48·85 per cent. of oil is obtained from the kernel.

TUNNY FISHERIES IN KYUSHU.

Tunny are caught along the Pacific coast of Japan, from Formosa as far north as the Hokkaido. The total annual catch varies greatly, but the average for recent years has been 25,000,000 pounds, valued at £200,000.

In Kyushu the most profitable tunny fisheries are found along the south-eastern coast of the island. Large trap-nets, 150 to 300 feet wide at the mouth and 500 to 900 feet long, are favoured in this district. The rope for the nets is about ¼-inch in diameter and is made of rice straw. While not as strong as hemp rope, it is more clearly visible under water and serves better to keep the fish within the desired limits. The mesh of a trap-net at the mouth is very large (about 3 feet), but decreases in size, with the distance from the mouth, down to as small as 1 inch. The net is set in 35 to 40 fathoms of water, with the mouth facing the direction from which the fish are running. A net of straw rope, with a 3-foot mesh, is stretched from the trap-net to the shore, and another net of the same sort is stretched from the trap-net well out across the course usually followed by the fish.

Two large boats, each about 40 feet long, and three to five smaller boats are used in placing the nets. When large schools are running an additional boat remains after the nets are placed, with an extra net to be used as needed to guide the fish into the desired course. Men stationed on heights overlooking the sea watch the course of the schools of fish, and signal to the men in the boats the proper direction in which to extend the nets.

According to a report by the United States Vice-Consul at Nagasaki, bays surrounded by high, well-wooded hills are considered the best places to catch tunny. The fish move from south to north in the spring, and from north to south in the latter part of the year. Tunny, as they enter a bay, circle around and leave it, following a fairly definite course, which is well known to observers. The local fishermen are guided by this knowledge and by a general familiarity with the annual migrations in selecting the places for the nets at the several seasons of the year.

The nets are usually drawn two or three times a day—at dawn, in the afternoon, and at midnight. When the fish are running in large schools and frequently, the nets are drawn as often as necessary to keep them clear. As the straw rope is not very strong, it is occasionally necessary, with an unexpectedly large haul, to take in the catch with a hemp net dropped inside the net of straw rope.

Fishing for tunny requires considerable outlay

of capital. It is necessary to pay a stated amount annually to the Government for the fishing rights, and to have sufficient capital to repair or renew the nets as frequently as may be necessary, whether the catches are large or small. A trap-net costs from £40 to £50, according to size, and seldom lasts longer than one season. Sometimes a period of small catches continues for several years, to be followed by a year or two of extraordinarily large catches. The years of plenty must yield profits large enough to make good the scarcity of the preceding years. Capital sufficient to maintain the business through years of loss is indispensable for ultimate success.

In the last few years Kyushu, as compared with other parts of Japan, has not gained much from its tunny fisheries. Under present conditions, a haul of ten to fifteen average-size tunny is not considered poor luck. This decline is not expected to last, and the fishermen confidently look forward to a return of the years of plenty.

Tunny is nearly always consumed in the local markets. It is very highly esteemed when prepared in the form of "sashimi" (the raw meat thinly sliced and served with soy sauce). Small quantities are canned, or dried after being boiled, and in that form it is sold as "katsuobushi" ("dried bonito," the bonito being usually preserved in this form).

The Government does not give direct financial aid to the tunny fisheries. It makes every effort, however, to preserve conditions favourable to the fishing industry. Care is taken to prevent deforestation of the hills surrounding bays which the fish frequent. There are several Government experiment stations where the forms and sizes of nets adapted to each variety of fish are studied, and where investigations of the seasonal habits of fish are conducted.

THE SWISS TOY INDUSTRY.

Until recently the manufacture of toys in Switzerland had not attained much importance. There were a few small factories in operation (three devoted exclusively to the manufacture of toys and several where toys were made in connection with sporting goods, wood carvings, celluloid articles, etc.), but their products were sold mainly in the domestic market. The foreign trade in Swiss toys was not large, amounting to £8,400 in the pre-war year 1913, and dropping to half that sum in 1915.

However, the war has brought about a general readjustment of practically every branch of activity, the toy industry included. Shortly after the outbreak of hostilities, the question was raised as to how the production, and at the same time the variety, of toys could most advantageously be increased in Switzerland. The reason for this interest in toy-making was that thousands of men who were formerly employed as carvers had been thrown out of work when the war brought the wood-carving industry to a standstill. These men were without means, and were unable to make a living for their families in any other way. The attention of the Federal and Cantonal Governments was called to the great similarity between wood-carving and toy-making, with a view to obtaining their approval of a movement to combine the two industries. The wood-carving industry being chiefly centred in the Bernese Oberland, the people in that district united to support the plan.

It was not the intention of those at the head of the movement to found new factories or encourage the investment of capital for the enlargement of plants already in existence. Their plan was to provide work for those men who, owing to the war, were thrown out of their regular employment; and the only way to do this under the circumstances was to organise a new home industry similar to what the wood-carving industry used to be. The natural result was that preference was given to making toys, and especially wooden toys. The matter was taken up in a most energetic manner, and no efforts spared to establish the new industry at least temporarily.

It appears from a report by the United States Consul-General at Zurich, that it has not been an easy task to introduce an almost new industry during war time. Not only are raw materials much higher in price, but they are also harder to obtain than under normal circumstances. Wages also have increased, and high freight rates, war insurance, etc., have adversely affected the industry. But in spite of these drawbacks the people in the Bernese Oberland were successful in obtaining Federal and Cantonal subsidies with which to purchase the necessary machines, tools, and models, and the manufacture of toys is now being taken up with great activity. Special courses are being given, in which the mechanical part of the industry is taught and workmen are thoroughly trained.

In order to familiarise Swiss buyers with the home-made toys, exhibitions were held in various large cities of the Republic. A fairly large variety of toys was displayed, some of the exhibits giving evidence of exceptionally skilled workmanship. Optimistic observers see no reason why this industry should not be permanently maintained, regardless of what conditions after the war may be. It is hardly likely that the competition of Swiss products in foreign markets will be soon felt, for the demand for toys in Switzerland so far exceeds the domestic production, that it will be some time before foreign outlets are needed.

As stated, Switzerland's export trade in toys is not large, and is quite overshadowed by the imports. Germany, Austria-Hungary, France,

and the United Kingdom are the chief suppliers of these imported toys; and, notwithstanding its own immense production, Germany normally is the best buyer of Swiss playthings.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

Taxable Clothes.—It seems a foregone conclusion that the luxury tax will apply to specified kinds of clothing, and no doubt a case in its favour can be easily made out. The objections, however, are not negligible, and it would be comforting to feel sure that the industrial reactions have all been carefully thought out. The French, in their haste, have classified silk stockings and underwear as articles which must, in all circumstances, bear tax upon their retail sale; yet it might be very difficult to show that real silks are intrinsically more luxurious than hosiery made of any other materials. A copy of this error should be easy to avoid, and presumably the British luxury taxes upon apparel and furnishings will fall upon goods selling at more than an allotted price. The number of bare textiles coming under tax should not be great, and it is permissible to suppose that the burden will be principally indirect and incurred upon the articles into which the finished products of textile industry are wrought. Even so, and allowing that money is prodigiously plentiful, the prospect is none too pleasing.

A Tariff on Art.—The production of idle luxuries may be a thing always to discourage, but to do this it is useless to make price the criterion. Cheap superfluities are more abundant than expensive ones. Garments at a high price are generally those into which enter the higher qualities of material, the finer efforts in design, and the most skilled workmanship. The ultimate price is not due nearly so much to the cost of the woven material as to the subsequent additions of dressmakers and distributors. If this price be driven down, the temptation to take the reduction out of the cost of material is strong; and if the effect be to run the price up, the time will come when the process restricts the sales of the finer products of textile industry. In either event an important humanising influence is lost, and in one measure or another it is sincerely to be feared that the attempt to tax luxuries will be prejudicial to the artistic development of industry. If it can be conceded that the profits will be one and the same, it is still not a good thing to discourage the production of the higher sorts of goods, and any mistake of that kind will have to be paid for in meal or in malt. The harm can be minimised by taking thought, but signs are all too few of anything more than a superficial examination.

Compensatory Markets.—It is not to be expected that spinners and others who found their sale or their chief market in Germany and Austria should share the full emotional fervour of the boycotting enthusiasts. Their tendency to exaggerate the importance to this country of the Central European markets may be set against the countervailing disposition to assume that these old outlets for yarn do not matter to our economy. The vital question is whether these Continental openings can be replaced, and upon this point Lord Balfour's Committee ventures an interesting opinion. It is believed that compensatory markets can be found for the wool tops, worsted, mohair, and alpaca yarns formerly sold to Germany, and that the fine cotton yarns lately consumed in that country can all be consumed in this and allied countries. Positiveness upon that point would be welcome, for there are various signs showing that access to English yarn supplies will by no means be despised by German consumers after the war. German textile operatives call, in a recent manifesto, not only for the free import of raw materials and yarns, but for fabrics and ready-made clothing. Their plight as consumers presses more heavily than their interest as producers. Herr Dettmann's public fears that the German market will be thrown open to all comers if raw materials are withheld from it are to the same point.

Cellulon.—Not often are so many inconsistent stories published about one and the same article as about the new German hope, cellulon. All accounts agree that it comes from wood-pulp, and that it is not made in the familiar way by twisting ribbons of paper into round thread. It is variously supposed to be exuded from small holes in a plate; to be moulded from wet pulp in passing over grooved drums; and to be a combination of waste cotton or wool-fibres and cellulose. It is commended as a thorough substitute for cotton, hemp, jute, and linen—which means presumably that a thick yarn can be made from it—and there is impartial, inexpert testimony that one sample of the cloth seemed very strong. Out of this welter of conflicting reports the safest supposition would seem to be that cellulon is a manufactured product, not of finished paper, but of paper-makers' half-stuff. It may be strong, and may be rendered more or less proof against water, but as nobody ventures to call it also light it may be believed to share the common heritage of these paper products. Factories to manufacture the stuff are going up, and in all probability good prices will be obtainable for it, in the absence of much better material. All the flattering accounts of the enemy's textile substitutes come from suppliers of the articles; the users employ resigned tones.

A New Journal.—In its guise as a monthly publication, the *Journal of the Textile Institute* is a vehicle for the proceedings of the parent body and for the communications of textile technologists. It sets, among textile periodicals, a new standard of concision of statement for which it may be hoped that a growing number of appreciators will

be found. The abstract of technical literature occupying one-third of its pages naturally does not rise any higher than its sources, and may be said to relate to documents of varying significance and value. The Journal will fulfil its predestined office in attracting to itself the original communications of discoveries made by specialists, and in this direction one example may be left to encourage another. In industries not far remote from the textile manufacturing trade there are admirably successful journals of the type that this one is endeavouring to become, and, given time and opportunity, the Institute Journal should establish itself impregnably also.

The Textile Institute.—The attention of testators and other custodians of wealth may be drawn pointedly to the £50,000 fund now being established under charge of the Textile Institute for the endowment of researches into the nature of textile fabrics and their uses in industry. Large sums of money have been somewhat easily made during the war by parties to the textile business, and the claims of its future should not need much pressing. Noble uses for money jostle each other in these days, but there need be no mistaking the nobility of aim implied in setting upon a scientific basis an industry which is the means of life to one and a quarter million people. So far as such a thing can be secured, the vesting of control in the hands of a body like the Textile Institute ensures competent administration, and the fund presents itself to those who have acquired wealth as a ready means of repaying an obligation.

OBITUARY.

The Earl of Rosse.—The Earl of Rosse, who had been a member of the Royal Society of Arts since 1909, died at his residence, Birr Castle, on the 10th inst., at the age of forty-four.

William Edward Parsons, fifth Earl of Rosse and eighth baronet, succeeded his father, who had also been a member of the Society for many years, in 1908. After being educated at Eton and Christ Church, Oxford, he entered the Coldstream Guards, whence he was transferred to the Irish Guards. He served in the South African War, and was awarded the Queen's Medal with three clasps. At the outbreak of the present war he rejoined the Irish Guards, and was severely wounded in the head in 1915. From this wound he never really recovered, and it was doubtless indirectly the cause of his sudden death.

GENERAL NOTES.

The Canal Question.—*Engineering* urges that in any great scheme of canalisation, such as is suggested as a post-war measure, we should find our capital expenditure out of all proportion to that of our Continental rivals, while the cost of maintenance and operation per mile and per ton would be excessive. Most of the Continental industrial districts, which are so well served in the matter of water transport, are comparatively flat, whereas in the United Kingdom the majority of similar localities are hilly. In Continental Europe there is only one lock for every five miles of inland navigation; here, taking the country through, there is a lock for every 1½ miles. Of our navigable inland waterways—4,053 miles—1,482 miles are natural river; in France, 4,392 miles out of 7,006 miles are natural; in Germany, 5,815 miles out of 7,038 miles; in Austria, 2,427 miles out of 2,722 miles; and in Russia, 23,211 miles out of 23,614 miles. When a year ago the Government took over the inland waterways it guaranteed the canal companies, but not the carriers, their net revenue of 1913. The carriers, by whom 90 per cent. of the traffic is done, are companies and individuals who own the barges and pay the canal companies for the use of the waterways. The *Times* states that the Canal Control Committee, of which Sir Maurice Fitzmaurice, C.M.G., is the chairman, has made financial recommendations to the Board of Trade for the purpose of enabling the carriers to fix rates that will divert additional traffic to the canals and pay the high wages which labour now demands. At the time the Government assumed control 1,200 barges were lying idle for want of crews. Large numbers of bargemen had joined the Army, and most of those who were ineligible as recruits were attracted to the railways and munition factories by higher wages. It is claimed that, despite adverse circumstances, the Canal Control Committee has already done much to relieve the congestion of the railways.

Concrete Ships.—Replying to questions in the House of Commons recently, the Civil Lord of the Admiralty said that the first concrete vessels were built in Italy, but they were of small dimensions and of no commercial value; in fact, some of them were rowing boats. One concrete vessel, with a dead-weight carrying capacity of 5,000 tons, had been launched in the United States, but it was not likely that it would come to this country. Every encouragement was being given by the Admiralty to this new industry, several newly-formed yards having been laid down specially for constructing concrete craft, while existing shipyards had been encouraged to form branch establishments for the same purpose, without interference with the building of steel vessels. Although at present no vessels of more than 1,000 tons were being constructed to the order of the Admiralty, there was a very urgent demand for vessels of small tonnage which could be rapidly constructed. In view of this, it was decided to concentrate on the smaller craft until more experience had been obtained as to the construction of such craft, and what was of much more importance, behaviour when at sea.

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NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Sixty-fourth Annual General Meeting, for the purpose of receiving the Council's report and the Treasurers' Statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new Fellows, will be held, in accordance with the By-Laws, on Wednesday, June 26th, at 4 p.m.

(By order of the Council),
GEORGE KENNETH MENZIES, *Secretary.*

INDIAN SECTION.

Thursday afternoon, June 20th; The RIGHT HON. E. S. MONTAGU, M.P., Secretary of State for India, in the chair. A paper by the HON. SIR DINSHAW E. WACHA, Chairman, Bombay Millowners' Association, on "Indian Cotton and the Cotton-Mill Industry," was read by SIR CHARLES H. ARMSTRONG, late Chairman, Bombay Chamber of Commerce.

The paper and discussion will be published in a subsequent number of the *Journal.*

EXAMINATIONS.

The results of the Stage I. (Elementary) Examinations, which were held from March 18th to 26th last, were sent to the centres concerned on the 18th inst. The results of all three stages of the March examinations have now been made known.

The time-tables of the 1919 Examinations have also been issued. The Easter examinations will be held from Monday, April 7th, to Monday, April 14th.

Those held at Whitsuntide will begin on Monday, May 26th, and finish on Wednesday, June 4th.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 24 ... Geographical Society, Burlington-gardens, W., 8 p.m. Address by one of the Canadian Ministers attending the Imperial Conference.

TUESDAY, JUNE 25...Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. 1. Dr. F. E. Hackett, "The Twist and Magnetisation of a Steel Tube in a Spiral Magnetic Field." 2. Mr. R. G. Allen, "The Absorption of Water by Vulcanised Fibre and Erinoid on Exposure to Moist Air, and the consequent Change of Electrical Resistance." 3. Dr. F. E. Hackett, "A Method of Obtaining Dry Steam without a Steam Trap."
Aëronautical Society, Central Hall, Westminster, S.W., 7.30 p.m. ("Wilbur Wright" Lecture.) Dr. W. F. Durand, "Some Outstanding Problems in Aëronautics."
Anthropological Institute, 50, Great Russell-street, W.C., 5 p.m. Mr. S. Ishii, "Sociology of the East Coast People of Formosa."

WEDNESDAY, JUNE 26...ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual General Meeting.
Public Health, Royal Institute of, 37, Russell-square, W.C., 4 p.m. Dr. A. M. Williamson, "The Housing Problem."

THURSDAY, JUNE 27...Royal National Pension Fund for Nurses, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual Meeting.
British Acetylene and Welding Association, Holborn Restaurant, W.C., 2.30 p.m. Mr. C. Bingham, "The Purification of Acetylene."

FRIDAY, JUNE 28...Chadwick Public Lecture, at the Surveyors' Institution, 12, Great George-street, S.W., 5 p.m. Professor D. W. Thompson, "Our Fisheries and the Food Supply. Lecture II.—The Catch by Net—or the Great Herring Fishery."
Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. 1. Professor E. H. Barton and Miss H. M. Browning, "A Demonstration of Coupled Vibrations." 2. Mr. I. Williams, "A New Method of Measuring Alternating Currents and Electric Oscillations."

SUPPLEMENT to the Journal of the Royal Society of Arts, June 21st, 1918.

ROYAL SOCIETY FOR THE ENCOURAGEMENT OF ARTS, MANUFACTURES, AND COMMERCE

165th SESSION, 1918-1919

BALLOTING LIST, WEDNESDAY, JUNE 26th, 1918, 4 p.m.

President.

H.R.H. The Duke of Connaught and Strathearn, K.G.

Vice-Presidents.

(Twenty-two to be elected.)

Sir Steuart Colvin Bayley, G.C.S.I., C.I.E. ....
Lord Blyth ....
Sir William Henry Davison, K.B.E., D.L. ....
Sir (Frederick) William Duke, G.C.I.E., K.C.S.I. ....
Sir Walter Egerton, K.C.M.G., LL.D. ....
Peter MacIntyre Evans, M.A. ....
Sir Robert Abbott Hadfield, D.Sc., D.Met., F.R.S. ....
Field-Marshal Sir Douglas Haig, K.T., G.C.B., G.C.V.O., K.C.I.E.
Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc. ....
Lord Islington, P.C., G.C.M.G., D.S.O. ....
Lord Leverhulme ....
Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S. ....
Sir Philip Magnus, Bt., M.P. ....
Viscount Northcliffe ....
Major-General Sir Desmond D. T. O'Callaghan, R.A., K.C.V.O.
Major Francis Grant Ogilvie, C.B., LL.D. ....
Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.
Hon. Richard Clere Parsons, M.A. ....
Sir Boverton Redwood, Bt., D.Sc., F.R.S.E. ....
Lord Sanderson, G.C.B., K.C.M.G. ....
Alan A. Campbell Swinton, F.R.S. ....
Sir Aston Webb, K.C.V.O., C.B., R.A. ....

Ordinary Members of Council.

(Twelve to be elected.)

Sir Charles Carrick Allom ....
Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. ....
Edward Dent, M.A. ....
Martin Onslow Forster, D.Sc., F.R.S. ....
Major Edward Humphrey Manisty Leggett, R.E., D.S.O. ....
William Henry Maw, LL.D., M.Inst.C.E. ....
Sir Francis Taylor Piggott, M.A., LL.M. ....
John Slater, F.R.I.B.A. ....
James Swinburne, F.R.S. ....
Professor John Millar Thomson, LL.D., F.R.S. ....
John Augustus Voelcker, M.A., Ph.D., F.I.C. ....
Sir Frank Warner, K.B.E. ....

Treasurers.

(Two to be elected.)

Carmichael Thomas ....
Sir Henry Trueman Wood, M.A. ....

Secretary.

George Kenneth Menzies, M.A.

Bye-Law 69.—"Every member *whose subscription is not in arrear* is entitled— . . . To be present and to vote at the Annual and all other General Meetings of the Society."
Bye-Law 83.—"Every member intending to vote at the election of officers may, if he shall think fit, erase any name or names from such Balloting List, and may substitute in the place thereof the name or names of any other qualified person or persons, and shall hand in to the Chairman such Balloting List as aforesaid, either with or without such erasure and substitution of names."
"Any Balloting List containing a greater number of names proposed for any office than the number to be elected for such office shall be absolutely and wholly void, and shall be rejected by the Scrutineers."

N.B.—The names in Italics are those of Fellows who have not filled the offices for which they are respectively proposed during the current year.

NO BALLOTING LIST can be received unless presented by the Fellow IN PERSON at the Meeting.

Journal of the Royal Society of Arts.

No. 3,422. VOL. LXVI.

FRIDAY, JUNE 21, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FINANCIAL STATEMENT FOR 1917.

The following statement is published in this week's *Journal* in accordance with Sec. 40 of the Society's By-laws:—

INCOME AND EXPENDITURE ACCOUNT,

January 1st to December 31st, 1917.

Dr.

	£ s. d.	£ s. d.	£ s. d.
To *Journal*, including Printing, Publishing, and Advertisements...		1,670 3 11	
,, Library and Bookbinding...........		63 6 1	
,, Medals:—			
Albert	20 13 0		
Society's	17 5 0		
		37 18 0	
,, Sections:—			
Colonial	47 0 0		
Indian.....................	67 0 0		
		114 0 0	
,, Cantor Lectures		50 3 0	
,, Donation to Board of Scientific Societies		20 0 0	
			1,955 11 0
,, Income Tax			311 3 1
,, Expenses of Examinations			3,499 1 0
,, House—			
Rent, Rates, and Taxes		848 17 11	
Insurance, Gas, Coal, Expenses and Charges incidental to Meetings		329 11 5	
Repairs..................................		51 7 0	
			1,229 16 4
,, Office Expenses:—			
Salaries, Wages, and Pensions		2,606 5 7	
Stationery and Office Printing		413 2 4	
Advertising..........................		18 10 6	
Postages, Parcels, and Messengers' Fares		165 16 11	
			3,203 15 4
,, Committees (General Expenses)			24 9 8
,, Interest on Bank Loan................................			75 17 5
			£10,299 13 10

Cr.

	£ s. d.	£ s. d.
By Subscriptions	4,105 18 0	
,, Life Compositions	561 5 0	
		4,667 3 0
,, Interest and Dividends on Society's Investments	442 0 10	
,, Ground Rents	367 2 0	
,, Interest, Dividends, and Ground Rents from Trust Funds for General Purposes	502 0 4	
Do. from Building and Endowment Funds..........................	21 14 7	
		1,332 17 9
,, Sales, etc.:—		
Journal	133 3 3	
Do. Advertisements	41 12 6	
Cantor Lectures.....................	7 0 10	
History of the Society...........	1 12 2	
		183 8 9
,, Examination Fees and Sale of Examination Programmes		3,665 16 0
,, Charges for Expenses for the Use of Meeting Room		103 8 6
,, Balance, being Excess of Expenditure over Income transferred to Capital Account (see Balance Sheet)		346 19 10
		£10,299 13 10

TRUST INCOME AND EXPENDITURE ACCOUNTS.

Dr.

	£ s. d.	Deficiencies on Trust Revenue December 31st, 1917. £ s. d.
BENJAMIN SHAW TRUST—		
To Balance, January 1st, 1917	14 19 0	
Less Interest on Investments	4 10 8	
		10 8 4
FOTHERGILL TRUST—		
,, Balance, January 1st, 1917	22 5 7	
Less Interest on Investments	13 3 4	
		9 2 3
,, Balance forward		354 17 5
		£374 8 0

Cr.

	£ s. d.	£ s. d.	Trust Accumulations December 31st, 1917. £ s. d.
JOHN STOCK TRUST—			
By Balance, January 1st, 1917		10 10 1	
,, Interest on Investments		3 7 6	
			13 17 7
NORTH LONDON EXHIBITION TRUST—			
,, Balance, January 1st, 1917		12 18 1	
,, Interest on Investments		6 10 0	
			19 8 1
DR. ALDRED'S TRUST—			
,, Balance, January 1st, 1917		36 10 0	
,, Interest on Investments		7 9 6	
		43 19 6	
Less Cost of Mr. Lawrence Weaver's Lectures		30 0 0	
			13 19 6
THOMAS HOWARD'S TRUST—			
,, Balance, January 1st, 1917		45 5 10	
,, Interest on Investments		19 19 7	
		65 5 5	
Less Cost of Professor Fearnside's Lectures	20 0 0		
Printing ditto	10 2 6		
Income Tax on Interest	4 19 11		
		35 2 5	
			30 3 0
OWEN JONES MEMORIAL TRUST—			
,, Balance, January 1st, 1917		79 6 4	
,, Interest on Investments		15 13 4	
		94 19 8	
Less Cost of Prizes and Medals	15 5 3		
Income Tax on Interest	3 18 4		
		19 3 7	
			75 16 1
MULREADY TRUST—			
,, Balance, January 1st, 1917		36 12 7	
,, Interest on Investments		4 4 8	
		40 17 3	
Less Income Tax		1 1 2	
			39 16 1
DR. SWINEY'S TRUST—			
,, Balance, January 1st, 1917		120 0 0	
,, Ground Rents (Income from)		185 17 4	
		305 17 4	
Less Transfer to the Society's Income and Expenditure Account		145 17 4	
			160 0 0
FRANCIS COBB TRUST—			
,, Balance, January 1st, 1917		12 18 1	
,, Interest on Investments		8 18 10	
		21 16 11	
Less Income Tax		2 4 8	
			19 12 3
LE NEVE FOSTER PRIZE TRUST—			
,, Interest on Investments		5 14 6	
Less Balance overspent, January 1st, 1917		3 19 1	
			1 15 5
CANTOR TRUST—			
,, Interest on Investments		137 0 4	
,, Ground Rents		141 0 0	
		278 0 4	
Less Transfer to the Society's Income and Expenditure Account		278 0 4	
			—
DAVIS TRUST—			
,, Interest on Investments		78 2 8	
Less Transfer to the Society's Income and Expenditure Account		78 2 8	
			—
			£374 8 0

1918.
Jan. 1. By Balance brought forward £354 17 5

BALANCE SHEET, December 31st, 1917.

Dr.

	£	s.	d.	£	s.	d.
To Capital Account :—						
As on January 1st, 1917 ...	23,292	17	3			
Less Income and Expenditure Account Balance	346	19	10			
				22,945	17	5
,, Bank Loan				1,900	0	0
,, Trust Funds :—						
Capital Account	14,579	0	2			
Accumulations under Trusts Income and Expenditure Account.........	354	17	5			
Sundry Creditors	10	2	6			
				14,944	0	1
,, Sundry Creditors				2,024	16	10
				£41,814	14	4

Cr.

	£	s.	d.	£	s.	d.
By Investments (see Schedule) :—						
As on December 31st, 1916 (as valued at May 31st, 1917)	18,061	0	5			
Purchase of £2,000 War Loan Five Per Cent.......	1,900	0	0			
				19,961	0	5
,, Property of Society (Books, Pictures, etc.)..				5,000	0	0
,, Trust Funds Investments (at cost, see Schedule)				14,579	0	2
,, By Ground Rents outstanding :—						
Trust Account	90	0	0			
Society's Account...............	169	18	0			
				259	18	0
,, Subscriptions outstanding........................				1,379	0	0
,, Sundry Debtors :—						
Journal	50	0	0			
Advertisements	52	18	9			
Repayment of Expenses for use of Meeting Hall	68	15	6			
				171	14	3
,, Cash at Bank on Current Account (less Cash in transit)				464	1	6
				£41,814	14	4

We have audited the above Accounts and Balance Sheet for 1917 *with the books, accounts, and vouchers relating thereto, and certify them as being in accordance therewith. We have verified the Bank Balances and investments.*

KNOX, CROPPER & CO.,

Chartered Accountants.

Spencer House, South Place, E.C. 2.
13*th June*, 1918.

SCHEDULE OF THE SOCIETY'S INVESTMENTS.

			Ground-rents (amount invested)	£10,496	2	9
£217	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock ...	158	8	0
£500	0	0	New South Wales 4 per Cent. Stock............................	415	0	0
£500	0	0	Canada 3½ per Cent. Stock	360	0	0
£100	0	0	Queensland 4 per Cent. Stock	80	0	0
£530	10	1	New South Wales 3½ per Cent. Stock	456	5	0
£500	0	0	Natal 4 per Cent. Stock	400	0	0
£321	15	9	Metropolitan Water Board "B." Stock..............................	196	6	0
£6	0	0	New River Company Shares	6	0	0
£3,000	0	0	Newcastle-on-Tyne 3½ per Cent. Stock	2,775	0	0
£3,403	14	6	India 3½ per Cent. Stock	2,317	18	8
£500	0	0	South Australia 4 per Cent. Stock................................	400	0	0
				18,061	0	5
£2,000	0	0	War Loan 5 per Cent.	1,900	0	0
				£19,961	0	5

TRUST FUNDS INVESTMENTS SCHEDULE.

	£	s.	d.		£	s.	d.
Alfred Davis's Bequest	£1,953	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	£1,800	0	0
Dr. Swiney's Bequest	4,477	10	0	Ground-rents (amount expended)	4,477	10	0
Dr. Cantor's Bequest	2,695	11	3	Do. do. do.	2,695	11	3
Mulready Trust	105	16	0	South Australia 4 per Cent. Stock	109	10	1
Howard Trust	571	0	0	Metropolitan Railway 3½ per Cent. Stock	510	9	5
Owen Jones Trust	522	3	2	India 3 per Cent. Stock	423	0	0
Dr. Cantor's Bequest	3,273	16	6	Do. do.			
	648	19	7	Bombay and Baroda Railway Guaranteed 3 per Cent. Stock	2,573	10	0
J. Murray and others, Building Fund	20	16	4	India 3½ per Cent. Stock	20	10	0
	38	11	0	5 per Cent. War Loan	54	18	0
Francis Cobb Trust	255	14	1	New South Wales 3½ per Cent. Stock 1930-50	250	0	0
Le Neve Foster Trust	105	11	7	3½ per Cent. War Loan	100	0	0
	42	2	1	5 do. do.	40	0	0
John Stock Trust	70	4	0	5 do. do.	100	0	0
Shaw Trust	93	12	0	5 do. do.	129	6	8
North London Exhibition Trust	134	17	0	5 do. do.	184	15	0
Fothergill Trust	272	7	6	5 do. do.	374	0	0
Aldred Trust	154	8	0	5 do. do.	210	17	6
Endowment Fund	394	7	0	5 do. do.	525	2	3
					£14,579	0	2

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING.

Wednesday, May 8th, 1918; SIR EDWARD ROSLING, Chairman of Council, Rubber-Growers' Association, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Barouch, Ladislas, London.
Brown, George, Greenock.
Clapperton, George, Oxford.
Claus, William Henry, Alderley Edge.
Fryer, Frederick George, M.I.Mech.E., York.
Pugh, Ralph John, London.
Talbot, Benjamin, Middlesbrough.
Taylor, Alderman Herbert, J.P., Eaglescliffe, Co. Durham.

The following candidates were balloted for and duly elected Fellows of the Society:—

Brown, Joseph Pearce, J.P., Plymouth.
Kingsford, William Edward, Cairo, Egypt.
McConnel, John Wanklyn, M.A., Manchester.
Ramsay, Alexander, Lincoln.

The paper read was—

SCIENCE AND THE RUBBER INDUSTRY.

By J. BRETLAND FARMER, M.A., D.Sc., F.R.S.,
Professor of Botany, Imperial College of Science and Technology.

I have been asked to give an address on the use of science to the rubber industry. The subject is much too large to be fully discussed in the time at our disposal this afternoon, and I am not going to attempt to deal with other than certain aspects of the matter with which I may claim to have some familiarity. But, after all, these happen to be among the more important aspects.

I propose, then, to invite your attention to a consideration of the nature of the services science has rendered to the plantation industry in the matter of the production of the raw rubber, and, without going into too great detail, to indicate the directions in which it appears that the industry can profitably make further use of such assistance.

As soon as we regard the matter carefully it becomes apparent that we are still lacking in a true perception of the relations that should exist between science on the one hand and such an industry as that of rubber-planting and producing on the other. Agriculture, generally, is at bottom an essentially scientific industry. Its carrying on, and especially its reasonable extension, depends fundamentally upon the utilisation of natural knowledge, which is natural science. The knowledge may be largely empirical, it may be very imperfect, but it must be there in some measure; indeed, below a certain level of knowledge the tracks are apt to lead straightway towards insolvency. In tropical agriculture this truth is more evident than at home. But that is only because in Europe we have a wide experience, reaching back for many generations, to go upon. In the tropical cultivation of the ancient crops practice is also, up to a point, admirable if somewhat stereotyped, just

as it is among the old-fashioned folk at home. But a *new* industry, developed under modern financial and other conditions, calls for new practice. New wine is said to burst old bottles, and we have had already some sharp lessons in the tropics on the folly of neglecting to get Nature ranged on our side in exploiting the natural wealth which lies to the hand of him who knows how to gather it.

Such an industry as that of plantation rubber is essentially a branch of applied science. The trouble that lies at the root of things is that people do not sufficiently realise what they mean by science at all.

Let me put the matter in another way. We can of ourselves never produce anything in this world—neither rubber nor anything else of a material kind. We cannot make a rubber-tree, nor can we make it grow or yield anything. What we can, and actually do, effect is to arrange the conditions within certain rather narrow limits, but the rest of the affair—the genuine constructive work—lies altogether outside our powers. It is here that knowledge comes in, the knowing of the conditions which are requisite in order that what we desire may be accomplished by the forces of Nature, so far as it may be within our power to co-ordinate their operation, and so to secure the object we have in view. This is why it is so much easier to destroy than to construct. A relatively small derangement is enough to bring about destruction; sustained effort and continual watchfulness are demanded to ensure that the forces we imperfectly understand, and only partially control, may act in the desired way over a period of time which may be, and commonly is, of long duration.

I have tried to make this fundamentally important matter as clear as I could in order to emphasise the real relations in which what we call science ought to stand towards the planting industry—or for that matter towards any other business which is concerned with the material and forces of Nature—if the industries are to get out of science anything like all the advantages she has to offer.

How, then, does the particular sort of knowledge which we call science differ from that which is reached by the empirical method of trial and error? As we have seen, the latter can carry us very far, though it is expensive to acquire. In ordinary agriculture it has taken us a long way and has reaped a large measure of success. But it has been acquired wastefully, and many of the trials have been ruinously unprofitable. Now it is the chief business of science to detect the hidden relationships of cause and effect. The phrase may be simple but if you try to analyse it, and to see what it really implies, you will soon discover it is not so simple as it looks at first sight. In Nature we hardly ever encounter a straightforward problem. Before it can be usefully attacked it has to be split up into a number of more elementary ones—easier to grapple with, but, unfortunately, not always easy to solve. When we have disentangled, or analysed, the immediate problem into its simpler components, and some of these have been more or less fully unravelled, we have really learnt much which, though perhaps not directly convertible into cash value, may well put us in a position so to improve empirical practice that the cash will flow in.

The German chemists spent large sums of money, variously estimated at a million or more sterling, in breaking up the big indigo problem into its simpler parts before they had found out enough about the matter to enable them well-nigh to ruin the indigo plantations with their synthetic product. Similarly, unless we succeed in properly and intelligently harnessing the natural forces, and in manipulating the natural material basis for the plantation rubber, it may well happen that the chemist will discover how to bring about, on a commercially paying scale in the factory, what the rubber plant effects within its own body—the production of caoutchouc. If he ever does this on a successfully competitive scale, the planting industry will have itself to thank for the closing down of the plantations. The raw materials, chiefly carbon dioxide and water, are available everywhere, and are abundantly at the disposal of the plant, while the sunlight which drives the living machinery is free to utilise. And if the planting industry fails to keep uppermost in a competition where the rival is handicapped with relatively costly raw materials, it will be due to a short-sighted reliance on defective or depreciated plant, and possibly to unimproved vital machinery which is not being economically driven by the sun's energy. In other words, to a neglect of disease and to a lack of breeding better strains of rubber plants.

It is fair to learn from others, even from our enemies. Thirty years ago the yield of sugar from sugar-beet was scarcely half what it is to-day. The agriculturists, largely German, co-operating with scientific men, rapidly improved their strains of beet, and succeeded in

largely undercutting the product of the sugar-cane, mainly because the West Indian planters continued to employ methods—if they could be called methods at all—which could hardly end in any way but disaster. I well remember the surprise I felt some thirty-five years ago at finding a beautifully equipped laboratory attached to a very small factory erected for the extraction of sugar in a Hartz mountain village. The laboratory was provided with all the latest apparatus, and was in the charge of a very able man. Nothing was left to chance, and every effort was made to understand the how and the wherefore of sugar production, not only from the beet in the factory, but from the raw materials in air and soil when they meet within the tissues of the beet. In such centres, and they were many, knowledge was being made, and although the problems that confronted those early inquirers were far less susceptible to analysis at that time than at the present day, the patient and dogged determination to improve the stock and the methods has justly earned a rich reward.

Now let us turn to the rubber industry and try to see how we stand in this matter. After a number of tentative attempts with a variety of rubber-yielding plants—*Ficus, Castilloa, Funtumia, Manihot* (Ceara), and others—the plantation industry has mainly centred its efforts on *Hevea*. It is not necessary to detail here the romantic episode of its acquirement, through Wickham, by Kew, and its distribution by that great establishment to the tropical regions of the Empire. But it should not be forgotten that this great wealth-producing agency in the British Empire was cradled in the scientific nursery at Kew. As it advanced to the productive stages it has continually invoked the assistance of science, which has been repeatedly able to short-circuit the dangerous and devious road of empiricism—a road strewn with the corpses of more than one industry, as in Ceylon and elsewhere. Soon after its introduction the inevitable onslaught of disease occurred. At first came the serious attack of *Fomes*, and mycologists were engaged to study the fungus and to devise remedial measures. That particular disease is now pretty well understood and under control, and I have met men who are inclined to think that the value of the scientific assistance rendered in that connection has been somewhat overrated. Such an attitude is plainly untenable. Because the remedy happens to be simple when you know what to do, when to do it, and how to apply it, the value to the industry of being in a position to adopt remedies at all is supreme. Such measures, however, could have only been employed when the full story of the cause of the disease had been elucidated, and for this the scientific methods of men specially trained in the laboratory and in the field were absolutely indispensable. When *Fomes* had been pretty well subjugated it was supposed by some that the troubles were at an end. But those who were accustomed to think in terms of cause and effect, whether they called themselves scientific or practical men, knew better. You cannot grow a huge, and practically continuous, acreage of any species, especially under tropical conditions, without a constantly present risk of the incursion and rapid spread of animal or vegetable pests, and in disease it is during the earlier stages, before it has got a big hold on the crop, that it can be most hopefully combated. Other diseases have made their appearance. Pink-rot, which spread with terrible rapidity, and almost threatened the very existence of the industry itself in some districts, was only got under control when the source of the virulent infection was discovered, by the efforts of Brooks, Sharples, and others. Root-collar disease has likewise proved a dangerous pest, but now that its life-history and its mode of attack are understood, it should also become amenable to control. The more recent onslaught of *Phytophthora*—akin to the potato blight at home, and especially in its ruthlessness—is giving trouble, especially in Malay, where it has recently appeared. A similar, and perhaps identical species, investigated by Petch, has been known for some years in Ceylon, where, however, it does not appear to be especially dangerous. But it must be borne in mind that it by no means follows that a disease which is virulent or mild in one climate or soil will necessarily preserve the same characters in regions where the physical or climatal conditions are different. The *Phytophthora* will need careful watching, especially in continuously damp climates.

It is not in the slightest degree probable that the planter will have peace from the attacks of fresh, and as yet unknown, pests. The history of plant pathology contains many records of fungi and other organisms which, from apparently relatively harmless antecedents, break out as violent parasites, whenever they find suitable host plants, which are constitutionally unable to keep them at bay. It must be remembered that these lower organisms produce countless hordes of spores or germs, which are, moreover, easily distributed very widely, and if

any of them happen to fall on an appropriate nidus, such as a suitable plant not specially protected, they will almost inevitably force an entrance with, it may be, disastrous results if timely measures are neglected.

Now, the rubber tree (*Hevea*) is not indigenous in the East, and we may take it as quite certain that there are many fungi and similar organisms, to say nothing of insects, against which it has no immunity, and to which, when the opportunity arrives, it will fall a prey unless extraneous and effective help is given. And in all these matters there is no time to waste in blind empirical trial. What is wanted is the very best advice that can be obtained, and it ought to be available at once. The proverbial stitch in time is likely to be worth, not nine only, but ninety-nine.

In the West Indies, where the planting of *Hevea* has, save in a very few estates, hardly got beyond the experimental stage, there has been but little trouble as yet. But the history of every new tropical enterprise is much the same in this respect, and the West Indian, like the Eastern planters, are likely to have enough on their hands. The case of sugar will not be forgotten by the enlightened body of men who are advising the West Indian estates.

But whilst the problems of dealing with diseases have imposed, and will continue to impose, upon any planting community the need of maintaining a scientific staff to look after the sanitation of the trees, even if it is only urged thereto by elementary considerations of common prudence, there are other aspects of scientific assistance which ought not to be lost sight of, as they are rather apt to be so long as the necessity seems less stringent.

There remains much still to be learnt about such relatively simple matters as tapping the trees. Parkin made a notable discovery when he established the existence of the wound response; and others, by anatomical investigations, have shown that the laticiferous system of tubes does not run vertically but spirally in the tree. This has given an important clue to a rational method of arranging the cut. But these things are, after all, only on the fringe of infinitely more important problems which ought to be seriously tackled, as they would have been tackled long ago if the leaders of the rubber enterprise had fully understood the power which a scientific knowledge of their living machinery is able to place in their hands. These all-important matters which I now have in mind may be shortly stated to be, first, the physiological significance of the production of rubber and its chemical antecedents, not to the *planter*, but to the *plant*; and, secondly, those scientific investigations which are conveniently summed up in terms of stock-breeding. Now these are large matters, and before they can be brought within the tangible reach of practice, a good deal of what is sometimes called pure science will have to be invoked. One is liable, when urging an embarkation on a research conducted without any *immediate* practical object in sight, to be reminded that the practical man is out to make money, and not to subsidise pure scientific research, which does not obviously or directly contribute to this result. This attitude is largely due to a misapprehension of the methods of science. In the larger affairs of life and business, it is not a paying or long-sighted practical policy to condemn the expenditure of every sixpence on Monday which fails to yield an obvious shilling on Tuesday. Still less is it a far-sighted view that nothing is likely to matter much to a concern, even one in which large risks are taken, because it has hitherto been able to pay a big dividend. What does matter is the establishment of a sound policy while business is good, and the furthering of future interests while things are still going well. Hard times and the stress of competition will come to rubber as to other industries, quite apart from the present difficulties. And one of the sides from which the attack is bound to be delivered is the chemical one.

Now chemistry has served the industry fairly well so far. The different coagulation methods, vulcanisation,* and various other ways of dealing with the latex and its products, have formed essential stages in the successful development of the industry as a whole. But chemistry is a two-edged blade, and when synthetic rubber begins to loom seriously in the future as a commercial proposition what will the British planters, and the shareholders in the plantations, have to say to it? At any rate they have done practically nothing to forestall it up to the present time.† Although the matter is attracting some attention in the circles that largely control the industry, there is little evidence at present of any adequate appreciation of the real

* Plantation rubber still needs much chemical investigation in order to perfect its most profitable vulcanisation.

† An American combine in East Sumatra is doing, with characteristic thoroughness, far more than the British organisations. They employ a staff that is both adequate and well paid, and will certainly reap a well-deserved profit.

nature of the task with which they are confronted. It is not, of course, unlikely that some improvement may be effected by mere empirical selection, whether of cuttings or by seed. But it is well known that there are rather special difficulties in the way, quite apart from all questions of influencing resistance to disease. For example, a tree may yield well for a time, and then fall off, only to become a good yielder later on. Others again behave differently, and are regularly either good or bad. But these facts evidently afford important clues to profitable lines of investigations in the future. Meantime breeding work is being conducted in Ceylon and perhaps elsewhere—a beginning has been made in a very small way at Singapore—on an altogether preposterously inadequate scale.

Furthermore, unless breeding operations are placed under the direction of men who thoroughly understand what they are about, and who are aware of the great complexity of the problem, the money and time expended will almost certainly be thrown away.

Breeding experiments are hardly likely to be of much value if they are confined to empirical and haphazard lines. A well-staffed and well-equipped experimental station and laboratories, devoted to breeding and kindred problems, ought to be provided in each of the main rubber-growing regions, and there ought also to be a settled policy of research. And by research I do not mean a concentrated effort to grasp at once at practical results, but to acquire knowledge—knowledge which when properly utilised will pay well. It is no use expecting to get big results in a few years, and hence the stations must be placed on a practically permanent basis. Nor is much likely to come from an establishment in which only breeding, in its narrower sense, is conducted, and it is but fair to put this aspect of the case forward. I suppose if one were to ask a planter what he expects to get out of the money devoted to maintain a breeding institute, the answer would be, Better yield, and a stock more immune from disease. This latter point is, however, fraught with especial difficulties, particularly if it has to be (as it should) combined with increased yield. For a moment's reflection will show that diseases are many, and their modes of attack diverse. Hence it is not at all probable that we shall ever raise a stock capable of withstanding all pests, although it may well be that resistance to some will prove to be quite within our power. Nor is any full measure of reward likely to accrue from breeding for yield, until we know something definite about the factors of which yield of caoutchouc is an outcome. But please do not think I take a gloomy view of future possibilities. The possibilities are great, but they will only be realised if we set about intelligently to make them materialise. We shall want, to begin with, real and accurate knowledge as to the significance of rubber and its chemical precursors in the tree. This will give us a genuine basis on which to go ahead, for it will afford clues which are as important from a breeding point of view as they are from a cultural one. In other words, we shall have begun to dissect the big complex problem into smaller ones, for which we may hope sooner or later to discover the solutions. But the sort of knowledge required is not mere speculation, such as whether the use of the latex is to heal wounds, or render the plant distasteful to animals, or any of those other functions which idle and rather childish guesses have suggested for it. We want to know precisely what is its physiological meaning, and all about its actual formation, and then we may hope to realise and control the conditions that make for its production within the plant. That it is related to the carbohydrate metabolism is certain, and that it stands in some sort of connection with resin is also pretty clear. And this last is a point of special interest, inasmuch as resins are present as more or less of a nuisance in all latices. The problem is not a simple one. Its solution may well tax the brains of the ablest men. But without doubt it ought to be taken seriously in hand, and that with as little delay as possible, for it is of really first-rate importance. It may be that the full solution is still far off, but the knowledge gleaned by the way is certain to repay the outlay—but only on one condition, that really able and well-trained men are engaged upon it. Anything else will be merely throwing time and money away.

Another set of problems will have to claim the attention not of rubber-planters only, but tropical agriculturists generally. In Europe and America the soil has, for some years, been looming ever larger in the minds of far-sighted men who are directing the higher agricultural practice. With more intensive cultivation, and the much greater yield arising therefrom, the soil has had to be investigated from the chemical, physical, and the biological points of view. The upshot of the whole matter has been to emphasise the unexpected importance of the biological aspect of the case. The fungal flora

and the micro-organisms of both animal and vegetable nature exercise an immense influence on the fertility or otherwise of the soil.

In the tropics the soil problems are bound to call for a far greater share of attention than they have hitherto received. In Ceylon, for example, it is generally recognised that there are difficulties in replanting estates. The action of the sun and rains on the land tends to destroy its fertility, partly by the mere physical action of removal, but partly also by the prejudicial effects of direct sunlight on the soil. The problems are not quite identical with those that are before us in the temperate climates, but they are not less important if we desire not only to increase, but even to conserve the capital value of the land.*

I have endeavoured to indicate very briefly some of the main directions in which science has aided, and in which it can further aid the great tropical plantation industry. I have also attempted to point out some of the chief difficulties that lie in the way of rapid results, because expectations unduly aroused are apt to be followed by correspondingly unfounded depression if not by irritation. It now remains for me to venture to suggest certain quite general lines on which this assistance, so essential to the well-being of the planting industry, might be most usefully increased and organised.

It must, I think, be clear to anyone who has watched the progress of most of our great commercial enterprises, that one of the commonest causes of arrest or decline lies in a certain lack of imagination which seems to be one of our national defects. The bird in the hand is really not always worth two in the bush, but we are rather too apt to grudge expenditure which gives no immediate promise of a tangible return. Our attitude to so-called "applied science" affords an illustration of this. Thus, when we have grasped the fact that we require scientific assistance to enable us to cope with the natural difficulties of disease and so on, we get out our mycologists, chemists, entomologists and what not, and then set them down mainly to do routine work—to deal with current difficulties only. No serious attempt is made to tackle the really big problems. We have, as I have already remarked, no adequate establishments to deal with the important matter of breeding. It is true that Ceylon has advanced a little—a very little—way in this direction. But it is quite certain that nothing very much can reasonably be expected to come of it on the present lines. Provision in the tropics should be made for such work on a liberal scale, and there ought to be no question of a five or ten years' scheme, but it will have to be secured on a permanent basis if any real good is to come of it. A well-staffed and well-found establishment will certainly, in the long run, repay all the expenditure many times over, but results of immediate practical value are not likely to come in this or next year, nor ought they to be expected or demanded.

This is perhaps not the occasion on which to raise or to discuss details of high policy, but in general terms it is safe to say that the matter ought to be taken in hand by the governments specially concerned, and administered by a body on which the planting industry, and also the relevant branches of science, are properly represented. Such a combination of official, practical, and scientific men ought to be able to ensure that the work would be carried out on well-considered lines. The three lines of interests, if I may use such a term, would view the matter from different angles, and although there might be differences of opinion as regards details, the general outcome of such co-operation should make for real efficiency. But, as I have already said, it would be essential that the enterprise should be definitely freed from the start from all demands for early practical results. And furthermore, when once the general lines have been laid down, and good men have been secured, those responsible for conducting the experiments must be given as free a hand as possible—and the less said about time-limits the better.

I believe it would be of great advantage if a suitably constituted committee were formed to serve in this country in connection with any such schemes. The functions of such a committee evidently should not be administrative, otherwise friction would almost certainly arise, and it might seriously impede the usefulness of an institute working in a distant country and confronted with conditions that might be imperfectly understood by persons living at home, and unfamiliar with local circumstances. But a home committee, charged with advisory functions only, would serve the useful purpose of bringing the tropical institutes into direct contact with the clearing-house of European knowledge, both economic and scientific. From the latter point of view at any rate, such a connection would seem to be eminently desirable,

* The American combine already alluded to have a soil-chemist on their scientific staff.

inasmuch as the results of the rapid advances which are being made in scientific knowledge and outlook would thus be rendered easily and naturally available to those engaged on the more specialised work of the institute or institutes. And such an association or committee, by furthering the aims and objects of the several institutes that may be brought into being, could not fail to react beneficially on the planting industry as a whole. Its efforts should be the more acceptable since matters affecting individual trade interests would lie entirely outside the terms of its reference.

The germs from which such organised institutes as I have indicated might be developed, are already in existence in the various agricultural departments of Colonial Governments, while influential bodies of men interested in the plantations have shown that they take an enlightened view of the situation. Notably, the Rubber Growers' Association, the Malay Planters' Association, and the Ceylon Planters' Association have exhibited a readiness to avail themselves of scientific assistance, and at their own cost. If they so chose, they obviously could do much, both by influence and material support, to promote the establishment of real research institutes, just as they have already done in securing what may be termed *ad hoc* scientific help.

Of course the scheme would cost money, but the expense would be very small in comparison with the magnitude of the interests at stake. At the present time, in the Middle East, if one takes the total proportion of revenue from the government and planting sources that can fairly be charged to expenditure on science in rubber production, it only amounts to a few thousands (say £12,000) per annum. The estimated value of the last year's crop is about £50,000,000 sterling. In round numbers this means less than sixpence per £100, but even of this only a small fraction is spent on research and investigation. Put in another way, the cost of science, as actually and directly provided by the industry itself, has been calculated to be about equivalent to the hooping used for binding the cases in which the rubber itself is exported. This scarcely strikes one as an adequate proportion to spend by way of insurance on the only effective means of combating disease, and of forestalling chemical synthesis.

To sum up then, science has been invaluable in the service of the rubber plantation industry, both from the chemical and also, and especially, from the biological side. If the industry is to continue to prosper, it has become essential that the investigations of disease and immunity, of the mode and significance of the latex and its constituents within the tree, as well as of the breeding of better stock, shall not only be maintained at their present level, but considerably increased. A distinction will have to be drawn between the necessary routine, *i.e.* scientific sanitation and inspection work on the plantations, and the research work largely to be carried on in the institutes. Both are essential, if the true interests of the rubber-planting enterprise and its future growth and prosperity are to be adequately safeguarded.

There are many other aspects of the services of science to the rubber industry which I might have developed, but as I had to make a choice I have selected those which seem to me to be of the most cardinal importance to the industry as a whole. I am aware that a considerably increased interest in scientific research is now being entertained in influential quarters, an interest which, one may be permitted to hope, will shortly become apparent in its effects. Meanwhile no one with a knowledge of the facts can doubt that, given a proper co-operation of science with practice, a larger—a much larger—return of rubber per acre is possible, and that this will be one of the most effective means of enabling the plantations to hold their own against competition and danger, whether from the synthetic factory or from other sources.

DISCUSSION.

The Chairman (Sir Edward Rosling) said it was over thirty years ago, about the time when he started tea-planting, that the first few rubber trees, the early descendants of those plants imported by Mr. Wickham into Ceylon, were being planted out in cocoa and tea estates, purely in an experimental way. He agreed with the author that true research was often apt to be starved by the desire for immediate results, as was only natural when men were dealing with a subject by which they had to earn their living. On the other hand, he thought the author had hardly done justice to those planters and others who had endeavoured to provide that research work. The rubber-growing industry, from a commercial point of view, could only be said to date from 1905 or 1906, and as far back as 1909 two research schemes were initiated, one under the auspices of the Rubber-Growers' Association and the other by the Planters' Association of Ceylon in conjunction with the Ceylon Government and the Imperial Institute. Those schemes were developing on more or less normal lines, the aim being to combine research proper with the correct balance

between the pursuit of immediate results and scientific research, when the war broke out and hindered all development on those lines. At the present time negotiations were proceeding with a view to co-ordinating existing research schemes in Malay, Ceylon and the Straits Settlements, and if those proposals materialised they ought to afford the means for carrying out research proper side by side with investigations on subjects of more immediate importance, such as disease. When it was realised that our knowledge of the rubber tree was so limited that no one could even hazard a guess of what the maximum yield from any tree would be when it was thirty years old, it would be seen what a very lengthy and complex question the subject of breeding for yield must be. Work of that kind could not be started for one year or five years: if the question of breeding for yield was to be undertaken properly, continuity of action must be ensured for anything from a quarter to half a century. At the present time there was an American combine carrying out most useful and up-to-date scientific work in East Sumatra. The combine was particularly fortunately situated in that it was self-contained, utilising its own products in its own factories, and having control of very large financial resources. The chief difficulty in dealing with research had been in co-ordinating and directing in a general way the work of the scientist in the East, and more especially in securing the right type of men with the right kind of training. Personally he was very hopeful with regard to the future, and it was a very happy augury that such an eminent scientist as the author should have given the careful thought to the subject which had been evidenced in the paper.

PROFESSOR WILLIAM BATESON, F.R.S., said the only aspect of the subject with which he had any special acquaintance was the question of breeding. He was very glad indeed to hear the author lay so much stress on that aspect, and felt sure that he was quite justified in looking forward to great results from the application of proper breeding science to the rubber industry. When returning home from the meeting of the British Association in Australia he visited a rubber plantation at Singapore, and it had always been clear to him since that time that rubber was a plant which was crying out for the scientific plant-breeder. At the present time the trees were grown from seed, and were then planted out in parts of the jungle cleared for the purpose, and when they were about six years old—that was to say, old enough to produce rubber—they were distanced from each other about 20 or 30 feet, so that each tree occupied a space of about 400 square feet; and it obviously mattered very much whether the tree was a good yielder or an inferior yielder, because it took the same amount of labour and space, although the produce might be very different. He had no doubt that trouble would be experienced owing to fluctuations with age and other conditions, but it should be possible for a person conversant with plant-breeding to exclude sources of error in practice. He had also seen the experiments going on in Singapore, and, although great pains were taken with them, they were carried out by men over-burdened with other work and without any special acquaintance with plant-breeding, and it would not be surprising if they met with comparatively little success. In one place he found that the seed was collected from the best trees, but no attention had been paid to the question of paternity. It would be very easy in the case of flowers like those of *Hevea* to conduct artificial fertilisation, and to ensure that the seeds were the produce of good trees on both the father's and mother's side. The question of breeding was a fundamental one, and it had to be brought home to those who had no personal experience of it that rubber trees were just like so many apple trees and crab-apple trees growing side by side in an orchard; and if rubber-growers were dependent on seed, as apparently the *Hevea* industry was at present, they were certain to be sowing trees of every kind of quality, whereas with comparatively little effort it should be possible to have all the trees good ones, as had been done in the case of other plants, such as the sugar-beet. He could not understand why rubber-growers did not propagate fine trees in the ordinary way in which fine trees were propagated, multiplying, by cuttings or in other ways, the best existing plants. Some difficulty appeared to have been experienced in propagating the rubber plant, and he would like to ask what the difficulty was that prevented fine rubber trees being propagated, and caused planters to rely entirely upon seed. He thought that in the case of tropical products, such as rubber and jute, when proper breeding was applied, as it certainly would be in the future, changes of the most extraordinary description might be anticipated.

PROFESSOR H. E. ARMSTRONG, F.R.S., said that, on his way home from Australia, he visited Ceylon largely with a desire to learn as much as he could of the rubber industry, and although the time he had was very brief he managed to see a good deal of it. He felt that no adequate scientific attention had been paid to the industry in order to solve the many problems that had to be considered. When one recollected what had been the history of cinchona and coffee in Ceylon, for example, one felt rather suspicious that something of the same kind might happen to rubber, and that it might fall a victim to disease in the same way that coffee did. In the case of cinchona, the industry had been lost because proper attention had not been paid to its development; but in the case of coffee the decay of the industry was due to the action of a fungus. From what he had learned in Ceylon he rather thought that a good deal was done in advance to prepare the way for the fungus. During the past three years he had been directly connected with the efforts that had been made for the resuscitation of the indigo industry in India, and the principal difficulty experienced in that direction was an agricultural

difficulty. It was difficult to get a crop, and it was impossible to raise seed in certain important areas. The reason why a crop could not be obtained was that there was phosphatic starvation of the soil, which had so small a quantity of phosphoric acid that the plants would not grow. When phosphatic manure was applied a good crop and good seed were obtained. One point that struck him very much in Ceylon was the absence of phosphates in the soil, and he was inclined to think that the way was prepared for disease in the coffee plant by that absence of phosphates. The same kind of thing was very likely to happen in the case of rubber, and there might be a sudden failure of the rubber crop in years to come when the phosphates in the soil had been worked out. The primary point that required special consideration in Ceylon was the question of the mineral content of the soil. The same thing occurred in Australia, where in many areas wheat crops could not be grown because the amount of phosphate was below the necessary minimum, and phosphates had to be put on the soil in order to obtain any crop. He was so impressed by the situation that when he was in Colombo he wrote a letter to the *Times of Ceylon*, in which he drew special attention to the point, and said that he could not discover that planters were in any way alive to the need of placing their industry on a scientific footing at all comparable to that on which the manufacture of dye-stuffs in Germany had long stood. The few isolated scientific workers on plantations had their hands too full of routine work to carry out the preliminary inquiries that were necessary, and the services of a staff of highly-trained and competent men were required. He made the suggestion that the Government should intervene, and levy an insurance tax of a halfpenny per pound upon all rubber estates in British possessions, but that scientific investigations should be carried out under the supervision of those engaged in the industry, the task of the Government being that of enforcing an adequate scientific inquiry. If the amount so raised were devoted to scientific inquiry in connection with the rubber industry, it would be a small sum to pay for insurance, and would lead to a very great development of the industry. He still thought that some such measure as that must be adopted. It was no use leaving the matter to private enterprise in the first instance; the State must enforce a proper measure of scientific inquiry being taken without loss of time.

Mr. Herbert Wright thought that any money spent on investigating disease in the rubber plant meant making more money, and that very rapidly. Very few people realised how the British people had acted as pioneers in connection with the plantation industry. There were something like two million acres of rubber in the world, and British people owned approximately 75 per cent. of that acreage—in other words, they owned 1,500,000 acres of rubber. It was difficult to forecast the yield from rubber trees, but he thought that ultimately, subject to labour and diseases permitting, British interests in plantation rubber were likely to yield approximately 250,000 tons of rubber annually. If that rubber was valued at pre-war prices, about £300 per ton, it would be seen that British people owned plantations which could produce annually rubber valued at £75,000,000. If two-fifths of that revenue come to this country for taxation purposes, it would yield a sum of £30,000,000 annually, and that showed that the plantation industry was a real asset to the British Empire. Every tree saved from disease meant more produce, more employment for British people, and more revenue for Great Britain. He hoped that every endeavour would be made to improve the plantations already established, and that rubber-growers would not rest content with the work that had been accomplished. With regard to diseases something had already been done, but, in his opinion, not nearly enough. Even some directors of rubber companies, and certainly many investors, would be very much surprised to know the extent to which the various parasites affecting the roots and bark of rubber trees had taken hold of plantations. The number of scientific officers engaged in mycological work in the tropics was very small. There was not one mycologist even for 100,000 acres of British-owned rubber, and that meant that there was not one mycologist even to attend to a property worth £10,000,000. Almost every mycologist in the East had been trained under the author's direction or had come under his influence in some way, and the author would agree that every mycologist in the East had far more work put upon him than he could possibly carry out. If diseases overtook rubber plantations in the East the responsibility would not be upon the mycologists but upon directors of companies and scientific institutes. In pre-war days it was impossible to find in this country men fully trained to carry out the necessary research in mycology in the East. He had sent many men to the East in connection with research work, and especially in connection with fungi, and in some cases he had had to send men to Germany to complete their education. Since one or two years before the war, however, it had been possible to train and equip men at the Imperial College of Science quite as well as they could be trained and equipped in Germany. Professor Farmer had made the mycological department of the Imperial College second to none in Europe, and the least that directors of plantation companies could do was to take his men as soon as he pronounced them competent. The future of the rubber-planting industry depended mainly on the overcoming of disease, and if the subject was not approached in a very bold and generous spirit an industry would be lost which was of real value to the Empire.

Captain A. W. Hill (Assistant Director, Royal Gardens, Kew) said that an important factor in connection with rubber plantations in the East

was the question of the seed from which the plants had been grown. When there was a boom in rubber-planting a few years ago there was a great desire to get seed and to start plantations. Seed was taken from wherever it could be obtained, and it might very probably be found to be the case that plants which yielded seed quickly were not necessarily plants which yielded the greatest quantity of rubber. There must be a very large number of plantations made up of trees grown from seed which nobody knew anything about. Again, it was very often thought that if a certain number of trees on a certain acreage produced a certain yield, twice that number would produce double that yield. That was an idea very prevalent in plantations on the Gold Coast, with lamentable results, and he thought there were estates in the East where the same opinion was held. With regard to the cuttings referred to by Professor Bateson, in the early days they were made at Kew with some success, after the practicability of this method of propagation had been demonstrated at Calcutta. Probably the rubber tree was one of those plants from which cuttings had to be taken at a special time of the year in order to be successful; but he thought that the reason why people had not troubled very much about cuttings was because of the great ease in obtaining seed and its good germinating qualities.

Mr. H. A. Wickham said he had been instrumental in the introduction of the rubber tree to the East from the Western tropics. He thought the fact had been overlooked that the rubber tree was a large forest tree, and it had been up to the present day and still was altogether too closely planted. Rubber estates had been looked on too much in the light of tea estates or coffee estates, instead of being treated on forestry lines. In his original report to the Government of India he suggested that a tree of the order and habits of growth of the rubber tree should not have been given a less spacing than half a chain, *i.e.* 33 feet. As a matter of fact, they were standing in various spaces at a distance of 12 feet or 15 feet apart, and under those conditions they never had a fair opportunity to develop. With regard to systematic clean cultivation, constant hoeing and forking had caused the surface soil to be drained into the rivers and so carried away, and he had come across places in Ceylon where one could actually pass one's arm underneath the roots of the trees. From his experience of similar cultivation—for instance, the cultivation of the chocolate tree—he could say that if the soil was kept heavily mulched the yield could be doubled. One had to aim at forest conditions, and conserve the surface of the soil. If the surface soil was kept covered by a heavy mulch it became mainly formed of the intestinal castings of earthworms, and the soil underneath the mulch was perpetually moist and resembled garden mould. The great point for the practical planter was to keep his trees in good health, and that could be done by approximating to their natural requirements and conditions as nearly as possible. He had been watching the industry for many years, and he thought the yield per acre obtained at present was not as great as it ought to be. Taking 350 lb. as the average yield per acre, he thought that was only about one-third of what the yield ought to be at the present day. With regard to rubber-curing, in his original report he suggested that the basis of starting curing should be taken from the standard rubber of the day, namely, hard-cured. His suggestion was put on one side as empirical, and the consequence was that the industry had now become standardised into two distinct markets. There was the plantation rubber sold as plantation rubber, and the hard-cured sold as hard-cured. He fully appreciated the value of science, but he did not think that science and empirical knowledge in any way clashed, and he thought the evidence derived from experience was of very great value.

The Chairman, in reply to Professor Bateson, said that no difficulty had been experienced with regard to cuttings from plants imported by Mr. Wickham in Ceylon, and he thought the chief reason why seed had been used to such a large extent was that there was no direct evidence of a great variation of yield amongst different trees, so that there did not appear to be any special advantage in propagating by cuttings. That did not bear on the scientific breeding of trees, which undoubtedly there would be great room for when further scientific research had been carried out in the matter. He thought industrial research might be defined as the proper balance between research proper and the pursuit of immediate or early results.

On the motion of the Chairman, a hearty vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

Professor W. Bateson writes as follows:—At the close of the meeting the Chairman, Sir Edward Rosling, declared that there was no direct evidence of great variation in yield of individual rubber trees, and that practical men did not, as a matter of fact, find such differences. In speaking of *Hevea* trees as differing greatly in yield I had in mind not merely verbal reports of persons familiar with rubber-growing, but several precise records of which the following are examples. W. H. Johnson, "Culture and Preparation of Para Rubber," 1909, p. 27, states that "the yield of rubber from different trees growing under similar conditions in the same plantation varies to an enormous extent." He then quotes experiments of Vernet (*Jour. d'Agric. Tropicale*, 1907), which gave differences ranging between the following extremes: in volume of latex from 4 to 48; in percentage caoutchouc from 29·23 to 39·74; in weight of dry rubber from 1·286 to 14·164. R. H. Lock, "Rubber and Rubber-Planting," 1913, p. 74, writes: "It is well known that rubber trees possess marked individuality as regards the amount of latex which can be drawn

from them. Tapping coolies, if left to themselves, soon discover these differences and confine their attention to the best yielding trees....Among a group of 29 trees of uniform age tapped daily, the highest and lowest average yields for the first 30 tappings were respectively 166 and 8 cubic centimetres. The circumference of these two trees was 52 and 32 in. respectively and they were not the largest and smallest trees in the group. The yield per inch of bark removed was in the ratio of 317 to 25, or more than 12 to 1." Lock adds that in Java the proportion of alkaloid in the bark of the introduced cinchona plants has been nearly doubled by careful selection, and that the variation in yield of *Hevea* is considerably greater than this. He strongly urges a rigorous seed-selection. There is plenty of further evidence to the same effect. Pending breeding experiments, the best trees should at once be propagated vegetatively. Though at Peradeniya only one cutting succeeded out of 3,000 (Johnson, p. 31), I have no doubt that with a little experimenting this difficulty could be overcome. In England *Hevea* strikes easily enough.

GENERAL NOTES.

Japanese Clock Industry.—The value of the clocks annually exported by Japan previous to the war was from 700,000 yen to 800,000 yen. Of recent years, the British Commercial Attaché at Yokohama states, the volume of exports has increased as the supply of German clocks was cut off, and in 1916 exports in this line from Japan were valued at 1,180,000 yen. During the last three and a half years Japanese clocks have been exported not only to China, the Straits Settlements, the South Sea Islands, and India, but even to the United Kingdom, France, and Italy, and it is believed that some portion of this new trade will be retained after the war. Latterly, however, clockmakers in Japan have experienced great difficulty in obtaining springs, and this has had a very adverse effect upon the trade.

The Oil-seed Industry of Rhodesia.—In view of the fact that even before the war it was becoming difficult to cope with the world's demand for oils and fats for the manufacture of margarine, and that this difficulty has been increased during the war, it is interesting to note that the cultivation of oil-seeds promises to become an important industry in Rhodesia. At present ground-nuts and sunflower seed are the only oil-seeds produced commercially, but experiments conducted at the agricultural experiment stations indicate that other oil-seeds may be grown successfully. Castor seed, sunflower seed, sesame seed, and linseed, grown at the Government Experimental Gardens in Northern Rhodesia, have recently been received at the Imperial Institute, and the results of examination in the Institute's laboratories are given in the new number of the Institute's *Bulletin*. The samples were entirely satisfactory. Before the war, sesame seed was chiefly crushed on the Continent, owing to the fact that in several Continental countries the inclusion of a certain quantity of sesame oil in margarine was compulsory, in order to facilitate detection of the margarine when used to adulterate butter. This factor raised the price of sesame seed, with the result that British margarine makers used other cheaper and equally good oils. Sesame seed is, however, now being crushed in this country—to which the Rhodesian seed will no doubt come after the war—and its use will be continued and extended for the manufacture of edible fats if the price of the seed remains at about the same level as that of other oil seeds.

Pusa Wheats.—Mr. J. MacKenna, C.I.E., Agricultural Adviser to the Government of India, in the paper on "Scientific Agriculture in India" that he contributed to the Society two years ago, said that a safe estimate of the gain to Indian wheat-growers, if all seed sown were of varieties like Pusa No. 12 would, it was calculated, be Rs. 15 per acre per year. The annual report on the progress of agriculture in India shows that through the medium of Pusa No. 12 the cultivators of certain districts of the Punjab and the United Provinces have increased their outturn by 25 per cent., while "Punjab 11" is expected to yield an additional income of at least Rs. 2 lakhs in the year to the cultivators of the 97,000 acres on which it was sown. In the Central Provinces, again, the 200,000 acres under various types of Pusa seed are bringing in an additional income of from Rs. 10 to Rs. 20 lakhs annually. We are told that Mr. and Mrs. Howard, whose experiments in cross-breeding wheat are so well known, believe that the present varieties are not "the last word," and that they will shortly be in a position to give the cultivator something even better. "When it is borne in mind that the area under wheat in the year under report amounted to nearly 33,000,000 acres, the possibilities here," says the *Pioneer Mail*, "are readily apparent."

Production of Steel Plates in Australia.—It is reported by the *Australian Industrial and Mining Standard* that steel plates have been produced for the first time in Australia at the Broken Hill Pty. Co.'s Steel Works at Newcastle. Two hundred tons of plate, 12 ft. and 22 ft. long, varying in thickness from half an inch upwards, are said to have been rolled in the four weeks ended February 6th. Some further modifications in the equipment are necessary, and these are being effected. The rolling of these plates will, it is believed, make it possible to build steamers in Australia constructed entirely of materials manufactured in the Commonwealth.

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Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi London, W.C. (2).

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FRIDAY, JUNE 28, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The One Hundred and Sixty-fourth Annual General Meeting for receiving the Report of the Council, and the Treasurers' Statement of Receipts and Payments during the past year, and also for the Election of Officers and New Fellows, was held in accordance with the By-laws on Wednesday last, June 26th, at 4 p.m., Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

The Secretary read the notice convening the meeting, and the Minutes of the last Annual Meeting.

The following candidates were proposed, balloted for, and duly elected Fellows of the Society:—

Basden, Duncan Frederick, London.
Bowie, James, Messrs. Parry & Co., Calcutta.
Brain, Henry Richard, London.
Bramwell, Samuel, J.P., Tunbridge Wells.
Brassey, Earl, D.C.L., London.
Breidenbach, Reginald Blackwell, East Croydon.
Chreiman, Miss Mary A., London.
Day, Charles, M.Sc., M.I.Mech.E., M.I.E.E., Stockport.
de Segundo, Edward Carstensen, A.M.Inst.C.E., M.I.Mech.E., London.
Dinsmore, John, Ballymena, Ireland.
Drake, William Armitage, Halifax, Yorks.
Flather, David, Sheffield.
Forbes, David MacHattie, Hawaii.
Garnett, George, Bradford, Yorks.
Hatchard-Smith, John, London.
Highfield, John Somerville, M.Inst.C.E., M.I.E.E., London.
Howard, Alexander Liddon, Totteridge.
Johnson, Hubert, Hull.
Khoo Sian Ewe, Penang, Straits Settlements.
Lamplough, Frederick, M.I.A.E., Feltham.
Liversidge, Engineer-Captain Edward William, R.N., Bermuda.
Low, Henry, Assoc.I.Min.E., London.
Major, John Lewis, London.
Matthews, Lieut. Frederic, Colchester.
Mhatre, Succaram Vassudeo, Bombay.
Mitchell, Harry, London.
Mitchell, Walter Ashby, Dundee.
Nichols, Ernest George, Manchester.
Owen, Councillor Evan, J.P., Cardiff.
Parlakimedi, The Raja of (Sri Sri Sri Krishna Chendra Gajapati Narayana Deo), Ganjam District, India.
Parshall, Horace Field, D.Sc., M.Inst.C.E., London.
Parsons, Charles Frederick, London.
Paul, William Hewitt, Birkenhead.
Perrott, Wilkinson Kidd, London.
Poulter, Captain Herbert William, Baghdad.
Prosser, John, Greenwich.
Richardson, Thomas Augustine, London.
Saklatwalla, B. D., B.Sc., Dr.Ing., Bridgeville, U.S.A.
Shipley, Rev. Samuel Paul, F.R.Met.Soc., Oakham.
Snow, Ralph George, Woldingham, Surrey.
Snow, William Ralph, London.
Strachan, Gilbert Innes, M.D., Cardiff.
Symington, William, Bickley, Kent.
Taylor, Charles Wardrope, South Shields.
Tooth, W. E., Burton-on-Trent.
Turner, William Lourence, Caldy, Cheshire.
Ung, B. H., B.Sc., Penang, Straits Settlements.
Vyle, Gilbert Christopher, Birmingham.
Wall, R. Howard, Chigwell, Essex.
Walters, Colonel Herbert A., V.D., Bromley, Kent.
Wisnom, Engineer-Commander William McKee, R.N., Dumbarton.
Wolseley, William Augustus, London.
Wordingham, Charles Henry, C.B.E., M.Inst.C.E., M.I.Mech.E., M.I.E.E., Redhill.

The Chairman appointed Mr. Denis R. Broadbent and Mr. Henry Hill scrutineers, and declared the ballot open.

The SECRETARY then read the following—

REPORT OF COUNCIL.

At the end of the Society's 164th Session the Council are glad to be able to congratulate the Fellows on a successful year's work. The papers read both at the Ordinary Meetings and at the Meetings of the Indian and Colonial Sections have reached a very high standard of excellence, and that they have been appreciated is shown by the fact that the audiences, as a rule, have been large—sometimes crowded—in spite of the pressure of business and the preoccupation which is so general at present. An even more hopeful sign is the increase in the number of new Fellows—which amounts to 373 this year, as compared with 164 in 1917. A pronounced increase has also been made in the entries for the Examinations, this year's total, 31,135, being 4,950 above that of 1917—a result which can hardly be regarded as other than remarkable considering the fact that many who would have been candidates in normal times are now serving in the Army.

I.—ORDINARY MEETINGS.

In his inaugural address, under the title "Science and its Functions," the Chairman (Mr. Alan A. Campbell Swinton) gave a rapid but brilliant review of human progress from its rude beginnings to the present day. In the course of this he showed that scientific research and investigation constitute the soul of industrial progress. Incidentally he brought out very clearly the points of similarity and difference between pure and applied science, and demonstrated, by examples from the history of wireless telegraphy and X-rays, how great discoveries which at first were purely theoretical have led to immense developments of the most practical and utilitarian importance. The address concluded with a plea for a better understanding by our Government Departments of the value of science, and the necessity for promoting its applications to industries; and at the same time a warning against such political interference as had for many years practically stopped the development of the motor-car industry in this country.

The two admirable inaugural addresses delivered by Sir Dugald Clerk in 1915 and 1916 led the Council to invite him to give the first Trueman Wood Lecture,* established in honour of the late Secretary. He selected for his subject "Discovery and Invention," and he gave a most lucid exposition of the essential difference between practical invention and scientific research. His thesis was illustrated by numerous instances from the history of invention, and the lecture must be regarded as a masterly discussion of a difficult and subtle problem.

One of the subjects to which the war has compelled us to give closer attention than in the past is the question of the relations between the State and trade. In order to organise and co-ordinate these relations the Board of Trade have instituted a new Department of Overseas Trade, of which an admirable account was given by its Comptroller-General, Sir William H. Clark. He described various developments which are being now undertaken, including the Trade Commissioner Service, the Commercial Attachés, the Consular Service, the special investigations of overseas markets, the relations between the Department and the commercial community, the methods of distributing information, and the holding of international and sample exhibitions.

Probably no paper read during the session attracted so much attention both within the Society and among the general public as that which Lord Leverhulme gave under the title "'Zero' of Capital and Labour." Dealing first of all with the question of the conscription of wealth, his lordship clearly showed that there is a point beyond which capital cannot be taxed without seriously crippling industry; and with regard to the graduation of income tax and death duties, he laid it down that the only limit is that point at which they yield the largest return to the State with the least injury to our industry. Lord Leverhulme expressed a confident opinion that if the country, as a whole, turned its attention to increasing its production to the extent of which it is capable, it would have little difficulty in clearing off the burden of debt imposed upon it by the war. He also urged the advisability of giving workers a financial interest in their work by means of co-partnership. Coming as it did from a great employer of labour who has tested his theories by wide practical experience, Lord Leverhulme's paper must be looked upon as a pronouncement of the greatest interest.

The relations between Capital and Labour also formed the subject of Mr. A. H. Paterson's paper, "The Foundation of Industrial Peace." Mr. Paterson is the Secretary of the National Alliance of Employers and Employed, a body which aims at establishing the friendliest and

* See also page 509.

closest relations between masters and men by bringing them together to discuss not merely business relations but also any questions in which they are jointly interested, such as housing, education and so forth; and he urged that it is only by the establishment of some such bond as this that we can hope for permanent industrial peace. Taken together, these two papers, with the very interesting discussions which they elicited, may be looked upon as a hopeful sign that the long hostility between employers and employed is drawing to a close, and that each side is beginning to see that its real interests and welfare are bound up in those of the other.

An interesting feature of the sessional programme was a series of papers dealing with the application of science to particular industries. In the first of these Professor J. Wemyss Anderson discussed the problems of the cold-storage industry. He pointed out its great and rapidly increasing developments in connection with meat, fish, poultry, eggs, fruit and cereals, and, in view of the numerous problems awaiting investigation in this connection, he made a strong plea for the establishment of institutes of research and schools of refrigeration in London and Liverpool, and for the provision of facilities for instruction in mechanical refrigeration at the principal technical colleges and schools throughout the country.

In the second paper of this series Dr. Reginald S. Clay, after sketching the history of the British pianoforte industry, described the steps that are at present being taken to improve the quality of British instruments. One of these is the establishment of a kind of hall-mark which should be a guarantee of the quality of a piano bearing it; a second is the standardisation of instruments; a third is the apprenticeship scheme, which is being conducted with good prospects of success under Dr. Clay's supervision at the Northern Polytechnic; and the fourth is the establishment of a school of research in connection with the piano, in which purpose piano manufacturers are co-operating, with the help of the Industrial Research Committee.

A subject of great topical interest was dealt with by Sir George Watson, Chairman of the Maypole Dairy Company, who described the manufacture of margarine in Great Britain. Immense strides have been made during the war, the average weekly quantity of margarine manufactured in this country having risen from 1,611 tons in 1913 to 3,564 tons in 1917. Incidentally a plea was made for linking the interests of employers and employed by means of profit-sharing and co-partnership, and the claims of science were handsomely recognised in the recommendation that in manufactures where chemists were employed they should be given seats on the board of directors.

Dr. W. Lawrence Balls, in an admirable paper, brought out the importance of the application of science to the cotton industry. He selected four examples—the cultivation of pure cotton; the study of the length of staple; the deterioration in the yield of Egyptian cotton; and the possibility of making cotton crop reports and forecasts more accurate and useful. Under each of these heads he showed in a striking manner what advances have been made by the aid of scientific study of the problems involved. In connection with the second head he exhibited a machine invented by himself by which the cotton fibres are mechanically sorted according to length and are then measurable with scientific precision. In the opinion of those present the machine was not only extraordinarily ingenious but also likely to prove of great practical value in the cotton trade.

What science has done, and what it may yet do, for the rubber industry was described by Professor J. Bretland Farmer. It should not be forgotten, he said, that "this great wealth-producing agency in the British Empire was cradled in the scientific nursery at Kew"; and he also referred to various critical stages in the history of the industry when science was called in to investigate and overcome the attacks of various pests which from time to time threatened its very existence. Even now a great deal remains to be learnt about tapping, the breeding of trees, and many other problems. A certain amount is being done in Ceylon and Singapore to provide opportunities for scientific research in connection with the rubber industry, and Professor Farmer suggested the general lines on which such work might be usefully extended and organised.

The immense demand for timber caused by the war has made the question of afforestation as prominent as it was at the close of the eighteenth century when the Society took up the matter, and, by the award of gold and silver medals and pecuniary premiums, was instrumental in encouraging the plantation of considerably more than fifty million trees. The present position of the timber industry was

described in an able paper by Professor Percy Groom. The importance of the problems involved may be gathered from the fact that in 1913 the value of the timber imported into the United Kingdom was over £42,000,000, and there was also consumed a large quantity of native-grown wood. After pointing out the principal steps to be taken to alleviate the threatened shortage in the future by the increased production of softwoods in this country, by afforestation in the British Empire generally, by the partial substitution of hardwoods grown in the British Colonies and Dominions for softwoods imported from foreign countries, and by economy in the use of timber, Professor Groom gave a valuable survey of the fundamental facts and principles that have been elucidated by research, and drew attention to some of the problems calling immediately for solution.

Mr. George Martineau, who may be regarded as the *doyen* of the sugar industry, contributed a valuable paper on "Sugar from Several Points of View." He set himself to show, from the history of sugar during the last sixty years, that nascent industries can be encouraged, research stimulated, and efficiency created, by a rational, well regulated, but moderate stimulus; that preferential treatment in home markets is the best, perhaps the only, way to give real confidence to capital; and that with that confidence, coupled, of course, with favourable natural conditions, British industries will flourish, and may even become capable of satisfying the whole consumption of the Empire.

An eloquent plea for devoting more attention to the study of organic chemistry in this country was made by Dr. M. O. Forster. He contrasted the situation in Germany, where 30 universities and technical high schools possess 157 professors of chemistry, with that in the United Kingdom, where 18 universities and 9 further educational institutions can only boast of 47 professors of chemistry. Moreover, as this disproportion has existed for many years, the present relative positions of the two countries in the matter of chemical achievement is not to be wondered at. The numerous and rapidly increasing applications of organic chemistry to industry were referred to. As a director of British Dyes, Limited, Dr. Forster naturally dwelt more particularly on its relation to the question of synthetic dyes, of the history of which he gave an admirable summary.

Professor Frecheville drew attention to the immense mineral resources within the British Empire which are at present entirely unexploited. In Australia and Canada, in particular, vast spaces remain unexplored, although there is good reason to believe that they abound in minerals. Mining industries have hitherto been left almost entirely to individual enterprise, and it was suggested that in future the Administration, both at home and in the Colonies, should adopt a more active policy in developing their mineral resources. Professor Frecheville also expressed the opinion that a Mineral Resources Bureau, if properly constituted, might play a most important part in such development.

Mr. Alexander Newlands, Engineer-in-chief of the Highland Railway, has devoted a great deal of time and energy to the study of water power in Great Britain, and he read an exhaustive paper on this subject, with special reference to Scotland. The tables published as an appendix show that Scotland possesses about 375,000 h.p. which is readily available, and Mr. Newlands urged its immediate utilisation in order to accelerate our industrial activities after the war.

Agricultural Machinery was the subject of a paper by Mr. F. S. Courtney, Consulting Engineer to the Royal Agricultural Society of England. A comprehensive account was given of most of the agricultural implements in use at the present day, and it was pointed out that in view of the shortage of labour and the necessity for producing home-grown food in greater quantities, the demand for machinery must rapidly increase in the near future. Incidentally, Mr. Courtney referred to the use of electric power for agricultural operations, which he believed would be extensively used before long. He suggested a system of co-operation by districts, and he also proposed that each area should decide on the types of machines which are best suited to their requirements. This would tend to the standardising of the industry, which, among other advantages, would save the manufacturer from the necessity of storing a great variety of spare parts.

Monsieur Paul Lambotte, Directeur des Beaux-Arts au Ministère des Sciences et des Arts de Belgique, had already given two admirable lectures in French before the Society. This year he read a remarkable paper in English on Ypres and other Flemish cities. His address was illustrated by a large number of lantern-slides from hitherto unpublished official photographs, which showed in graphic manner the ruin and devastation wrought by the Germans on sacred

and beautiful buildings. The meeting, which was crowded, was rendered memorable by eloquent addresses from the Archbishop of Canterbury and His Excellency the Belgian Minister.

In a long and exhaustive paper Major Sir Robert Armstrong-Jones discussed some of the mental effects of the war—the changes in the national outlook upon many subjects, and the reconstructive reforms that are likely to ensue as results of those changes. Among the various points dealt with were the Church, temperance, the care of child-life, the advances in medicine and surgery, the relations between Capital and Labour, and the amendment of the lunacy and marriage laws. The problems involved in the care and treatment of shell-shocked soldiers have educated public opinion in matters connected with lunacy, and a strong plea was made for the treatment of mental cases in their earlier stages, without first committing the patients to an asylum.

Lord Charnwood's paper on "Technical Training for Disabled Soldiers and Sailors" may be looked upon as complementary to the address given last session, in which Sir Arthur Pearson described the provision made for the treatment of those blinded in the war. Lord Charnwood discussed the steps taken by the Government to offer opportunities for technical training for disabled soldiers and sailors who are able and willing to profit by it, and the provision made for their maintenance during the period of instruction.

The future of aviation, and the use of aircraft for practical commercial purposes, were discussed by Colonel Mervyn O'Gorman. He indicated the lines on which aerial activity may be expected to develop, and the manner in which aeroplanes may soon be utilised for the transport of passengers and mails. He also drew attention to the immediate necessity for drawing up international agreements between ourselves and our Allies regulating air routes, alighting rights, etc.

The food situation in Germany, and the various systems of rationing adopted in that country, were described in a paper by Mr. Percy Shuttlewood, who, as an official of the Ministry of Food, had access to the most authoritative reports on the subject. It is, of course, difficult to get much in the way of reliable statistics from enemy countries, but a survey of the available facts and figures leads to the conclusion that the situation in the countries of the Central Powers is grave enough to be termed critical.

Amid the many subjects directly or indirectly connected with the war and with reconstruction, the artistic side of the Society's work was, perhaps, somewhat neglected this session. The only paper relating to art was by Mr. Maurice B. Adams upon the picturesque in architecture. His general thesis was a plea for simplicity and the adaptation of buildings to the end for which they were intended. Among other points he urged the desirability of employing local materials as far as possible, whereby styles of architecture were obtained which differentiated the work of one part of the country from that of another.

II.—Indian Section.

In the course of the session of 1917–1918 the Indian Section has entered upon its year of jubilee, the earliest meeting having taken place in 1869, a year which marks an event of immense importance to India—the opening of the Suez Canal. It may also be mentioned that for the first time in fifty years all the papers were concerned either with commerce or manufactures, at this moment more urgent than any other subjects within the scope of the Section.

Not the least valuable of the papers dealt with the first half-century of English commerce with India, 1608–1658, and was read by Mr. William Foster, C.I.E., Registrar and Superintendent of Records, India Office.

Previous to the war, two-thirds of India's commercial imports were obtained from the United Kingdom, while less than a quarter of her exports of cotton and other raw material came to this country. European foreign markets took one-third of the exports, and Asiatic countries the remainder. The Continent's share was equally divided between enemy countries and the Allies, but the latter in certain cases made their purchases of Indian produce through Germany or Austria. Two years ago Mr. D. T. Chadwick, I.C.S., now Indian Trade Commissioner in London, and Mr. G. W. Black, the present manager of the Alliance Bank of Simla, were appointed by the Government of India to visit Russia to see whether direct relations could not be completely substituted for enemy intervention, and generally to discover in what fresh ways Indian trade with that country could be opened out. On the completion of their inquiries in Russia, the mission was extended to France and Italy. The hopeful results of the investigations made in the three countries formed the subject of

an excellent paper read by Mr. Chadwick at the opening meeting, held on December 13th, under the chairmanship of the Under-Secretary of State for India, Lord Islington.

That remarkable member of the Parsi community, the late Mr. Jamsetjee Nusservanji Tata, had three chief ambitions in life—the smelting and conversion into steel of the undeveloped iron ore of India; the storage and utilisation of the heavy monsoon rains running to waste on the Western Ghats; and the foundation, on a large scale, of a scientific research laboratory. But he did not live to see the complete realisation of his aims. A very interesting paper on the first of the three projects—the Tata Steel and Iron Works—was read on January 17th by Mr. H. M. Surtees Tuckwell. Later in the session an equally instructive account of the second of the Tata schemes, the hydro-electric installation in the Bombay Presidency—"the finest of its kind in the world," as it has been described by a former Governor of Bombay—formed the principal part of a comprehensive paper by Mr. Alfred Dickinson on "Water Power in India."

A timely and useful contribution to a vitally important discussion, namely, the better utilisation of the Empire's resources in raw materials, was made by Sir Henry Ledgard in an able paper on "The Indian Hide and Leather Trade." Of India's various exports, hides are exceeded in value by only four other commodities, jute, cotton, food grains, and seeds. When war broke out this important Indian trade had passed into German hands. Sir Henry Ledgard made an earnest appeal to the authorities in India and His Majesty's Government to take certain measures indicated by him so as to prevent the possibility of the German monopoly ever being re-established, and to ensure that the industry shall in the future be wholly British and Indian.

At the concluding meeting, on June 20th, a paper by the Hon. Sir Dinshaw E. Wacha, Chairman of the Bombay Millowners' Association, on "Indian Cotton and the Cotton-Mill Industry" was, in the author's absence, read by Sir Charles H. Armstrong. The historical survey with which the paper opened included an interesting description of the old trade routes which in part may be re-established as one result of the military campaign in Mesopotamia. Sir Dinshaw Wacha then reviewed the rise and progress of the Bombay mills, and concluded by discussing the economic situation in view of the position of Japan as a large purchaser of Indian yarn and a keen competitor with Lancashire in the piece-goods markets of India.

III.—Colonial Section.

"Land Settlement within the Empire" was discussed at the opening meeting of this Section on November 28th, in an admirable paper by Lieut.-Colonel the Hon. Sir John McCall, Agent-General for Tasmania. His principal suggestions were that the Mother Country should provide free passages to the Oversea Dominions for desirable would-be settlers, ex-soldiers and others, and finance "co-operative schemes of settlement and public works." Sir John McCall, who was a member of the Committee appointed by the Government last year to inquire into the question of offering men of the fighting services facilities to emigrate after the war, also advocated the formation in this country of a Ministry of Migration.

At the next meeting the industrial resources of the Union of South Africa were reviewed by Mr. C. du Plessis Chiappini, who included in his comprehensive and interesting survey some candid observations on the much discussed question of "trade after the war." Viscount Gladstone, who occupied the chair, said that there is no limit to the development of food exports from South Africa, and another speaker, Baron E. B. d'Erlanger, expressed his confident belief that sooner or later Rhodesia as well as the colonies we have wrenched from German dominion and oppression will form part of the Union.

In a singularly able paper on "British Guiana and the Problem of its Development," Sir Walter Egerton explained why it is that that fertile but insufficiently populated possession is still almost as stagnant as were the West African colonies before Mr. Chamberlain went to the Colonial Office, and pointed out the measures that should be taken, *e.g.* railway construction, etc., to rid the ruling Power of the reproach that after a century's possession of a country equal in extent to Great Britain, only an area less than one-fifth the size of Kent is under cultivation, while most of the remainder is trackless forest and savannah unoccupied except by a few nomadic Red Indians.

A special and successful feature of the preceding session were the respective papers of M. Millet and M. Horn on the African possessions of the two Allies who are our nearest neighbours—France and Belgium. In

the session just concluded the African and other colonies of our oldest Ally, Portugal, were considered. In his attractively-written paper on the subject, Mr. George Young asked and answered the three following questions:—How was the Portuguese colonial power constituted; in what does it consist; and what contribution can it make to our reconstruction of civilisation?

IV.—Cantor Lectures.

Four courses of Cantor Lectures were delivered this session. In the first of these Professor H. C. H. Carpenter dealt with Progress in the Metallurgy of Copper. He gave a brief historical synopsis of the industry in early times, and of its rise and development in Great Britain. Copper-smelting was started in Swansea in 1717, and the industry made great progress in the eighteenth and nineteenth centuries. The conditions which made for this success were carefully analysed, as were also the causes for its subsequent decline. The development of mining and smelting in Chili, Spain, and Portugal were next described, and the discovery and mining of copper in the Lake Superior district. Subsequently the Australian deposits were opened up; Arizona and Butte entered into the producing areas; and recently progress has been made in Utah, Tennessee, Queensland, Tanganyika, Nevada, and Siberia. The chief features of modern copper-smelting practice in America—especially at Anaconda—were dealt with in great detail; and, finally, Professor Carpenter insisted on the need for exhaustive inquiry into the various aspects of the industry from the standpoint of Empire requirements, and of action to be taken on the basis of the results of the inquiry.

An interesting course on "High Temperature Processes and Products" was given by Mr. Charles R. Darling. In his first lecture he dealt with various methods of producing high temperatures, and described special fuel furnaces. The second lecture was devoted to high temperature processes, in illustration of which were shown the smelting of platinum and metals of high melting-point; welding and cutting by the oxy-acetylene flame and electric arc; thermit welding and metal spraying; while the production of steel and other metals by electric furnaces, and the fixation of atmospheric nitrogen, were also described. In the final lecture Mr. Darling discussed the principal high temperature products and their uses, particularly artificial graphite, carborundum, alundum, calcium carbide, siloxicon, carbon compounds, and aloxite.

It was somewhat of an innovation to select an economic subject for a set of Cantor Lectures, but the interest taken in Mr. Edgar Crammond's course justified the Council in their experiment. In three lectures Mr. Crammond discussed the economic condition of the United Kingdom before the war and after three years of war, and he also dealt with the real cost of the war and the problem of economic reconstruction. His arguments were illustrated by a great wealth of national statistics, on which he is a recognised authority.

The course on "Military Explosives of To-day," by Mr. J. Young, Chief Instructor in Science at the Royal Military Academy, Woolwich, attracted very good audiences. In the three lectures he dealt with propellants, high-explosive mixtures, and methods of detonation, illustrating each section of his subject with numerous experiments.

V.—Cobb Lectures.

A course of two lectures under the Cobb Trust was delivered by Professor Henry R. Procter, who gave four Cantor Lectures in 1899 on "The Manufacture of Leather." The subject of the present course was "Recent Developments in Leather Chemistry." The lecturer discussed the principal additions that have been made to the knowledge of the subject during the last eighteen years, and in conclusion mentioned a new process of chrome-tanning calculated to obviate the difficulties arising from the shortage of glucose and sugar. There had not yet been time to experiment to any great extent with the new method, but Professor Procter expressed his belief that it might be of very considerable use to the trade.

VI.—Special Lectures.

A course of three special lectures was given on a subject of great international interest at the present time—"The Freedom of the Sea." The first, by Mr. Gerard Fiennes, dealt with the question from the historical point of view; the second, by Sir Francis Taylor Piggott, from the point of view of international law; while the third, by Mr. John Leyland, analysed the modern German interpretation of the phrase, and showed how President Wilson's declaration is in conflict with the German claim.

VII.—Juvenile Lectures.

The Juvenile Lectures this session were delivered by Dr. P. Chalmers Mitchell, Secretary

of the Zoological Society of London. He selected as his subject "Animal Camouflage," and, aided by numerous lantern-slides, he gave an able exposition of the manner in which birds, beasts and reptiles contrive to make themselves inconspicuous amongst their natural surroundings.

VIII.—Albert Medal.

The Albert Medal of the Society for 1918 has been awarded by the Council, with the approval of the President, H.R.H. the Duke of Connaught and Strathearn, K.G., to Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S., "for his services in the application of science to the industries of peace and war, by his work as Director of the National Physical Laboratory since 1899, and as Chairman of the Advisory Committee for Aeronautics."

Sir Richard Glazebrook has been the Director of the National Physical Laboratory since it was established. Under his superintendence and control it has developed from a tentative institution with a moderate income and a very small staff, into the greatest official scientific organisation of the country, with an annual expenditure of £100,000 and a staff of over 500. Instituted with the view of providing for the testing and standardising of instruments, appliances and materials used for industrial, scientific and other purposes, and for carrying out such researches as might be required in the efficient discharge of such duties, it soon discovered that its subsidiary object was really its essential duty, and it became the centre of organised practical and industrial research for the kingdom. As its usefulness became apparent, its value was rapidly appreciated by the heads of engineering and industrial enterprises, who in many cases contributed very large amounts of money to provide the costly buildings and apparatus frequently required for elaborate experimental researches on an industrial scale. As the result, much valuable special information has been provided for such very varied applications as engineering and naval construction, the various branches of metallurgy, the numerous uses of electricity, aeronautics, glass-making, the manufacture of optical and other scientific apparatus, the treatment of refractory materials, and numerous other branches of scientific industry. Many of the problems submitted were of the highest complexity, requiring for their solution wide scientific knowledge, costly apparatus, close and long-continued attention, patient and enduring labour. A special and important part of the laboratory work was the improvement, perfection and standardisation of an infinite variety of gauges and measuring instruments, while side by side with all this advanced scientific work it has regularly and efficiently carried on a large amount of its regular routine of testing and reporting on the very considerable number of instruments regularly sent to it for the purpose of its valued certificates.

The Laboratory has, from its foundation, been under the control of the Royal Society, exercised through a committee representing the Society and six great technical institutions. This committee, under its eminent Chairman, Lord Rayleigh, has always taken an active and efficient share in the administration of the Laboratory; but it is recognised on all hands that a large share of its success is due to the Director's personal efforts and influence, to his singularly wide general knowledge of physical science and its applications, and above all to the ability he has shown in the personal guidance of many of the difficult investigations which he has had to conduct or to control.

The Council of the Society therefore welcome this opportunity of adding their testimony, by the award of the Albert Medal, to the value of the services which Sir Richard Glazebrook has undoubtedly rendered to the advance of scientific industry by his work as Director of the National Physical Laboratory.

IX.—Medals for Papers.

The Council decided to award six medals for the papers read before the Society during the present session—four for papers read at the Ordinary Meetings, and one each for those read at the Indian and the Colonial Sections.

The following awards have been made:—

At the Ordinary Meetings:—

W. Lawrence Balls, Sc.D., "Examples of Applied Science in the Cotton Industry."

George Martineau, C.B., "Sugar from Several Points of View."

Professor J. Bretland Farmer, D.Sc., F.R.S., "The Rubber-Planting Industry."

Martin O. Forster, D.Sc., F.R.S., "Organic Chemistry in relation to Industry."

In the Indian Section:—

H. M. Surtees Tuckwell, M.I.Mech.E., "The Tata Iron and Steel Works."

In the Colonial Section:—

Sir Walter Egerton, K.C.M.G., LL.D., "British Guiana and the Problem of its Development."

For many years it has been the practice that no medals should be awarded to readers of papers who had previously received medals from the Society or were members of the Council. Acting on this rule the Council were precluded from considering the following papers:—

At the Ordinary Meetings:—

SIR DUGALD CLERK, K.B.E., F.R.S., "Discovery and Invention."

LORD LEVERHULME, "'Zero'" of Capital and Labour."

MONSIEUR PAUL LAMBOTTE, "Ypres and other Flemish Cities before and since the War."

MAJOR SIR ROBERT ARMSTRONG-JONES, M.D., R.A.M.C., "Mental Effects of the War and their Lessons in regard to Medical and Social Reconstruction."

In the Colonial Section:—

LIEUT.-COLONEL THE HON. SIR JOHN MCCALL, M.D., LL.D., "Land Settlement within the Empire."

The Council, however, desire to express their high appreciation of these papers.

X.—SWINEY PRIZE.

The next award of the Swiney prize will be in January, 1919, the seventy-fifth anniversary of the testator's death. Dr. Swiney died in 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize on every fifth anniversary of the testator's death, to the author of the best published work on Jurisprudence. The prize is a cup, value £100, and money to the same amount; the award is made jointly by the Royal Society of Arts and the College of Physicians.

In accordance with the arrangement with the College of Physicians, the award next year will be for Medical Jurisprudence.

Any person desiring to submit a work in competition, or to recommend any work for the consideration of the judges, should do so by letter addressed to the Secretary of the Society.

XI.—OWEN JONES PRIZES.

Under the Owen Jones Trust, six prizes were awarded each year from 1878 to 1915 to Students of Schools of Art on the results of the National Competition held annually under the direction of the Science and Art Department, and its successor, the Board of Education. In 1916 the Board of Education decided to suspend the "National Competition," and it was therefore no longer available as the means of awarding the prizes.

Last year, however, the Council determined to offer the prizes direct to the Schools of Art, and to appoint their own judges to make the awards. All the difficulties of arranging for the reception and examination of the competing designs were removed by the kind co-operation of the Director of the Victoria and Albert Museum, who consented to provide the necessary accommodation at the Museum, and to offer all facilities for their proper inspection and the adjudication of the prizes.

The competition was limited to Designs for Textiles. 120 designs or works were sent in from 22 Schools of Art by 73 students. According to the report of the judges * the work submitted showed a high average of excellence, and the designs were exhibited to the public from July 23rd to August 25th at the Museum.

In view of the success of last year's competition, the Council decided, with the courteous consent of the Director of the Victoria and Albert Museum, to follow similar lines in 1918, and notice was accordingly issued last November to the principal Schools of Art that the usual prizes would be offered for (1) Chintzes, and other Stamped, Printed, or Stencilled Textile Materials; (2) Wallpapers; and (3) Tiles.† The designs have to be delivered at the Museum between the 24th and 29th of the present month.

XII.—"TRUEMAN WOOD" LECTURE ENDOWMENT FUND.

On the resignation of the Secretaryship by Sir Henry Trueman Wood in 1917, the Council resolved to institute an annual "Trueman Wood" Lecture to commemorate the services rendered to the Society by Sir Henry during the thirty-eight years for which he had held office. The first lecture of the course was delivered by Sir Dugald Clerk, to which reference is made elsewhere.‡

In order to place the lecture on a secure and permanent basis, by providing a substantial yearly fee for the lecture, it was subsequently decided to invite past and present members of the Council to raise an endowment fund, and in response to a notice circulated among them, the sum of £654 18*s*. was subscribed.

XIII.—EXAMINATIONS.

The examinations were held this year, as in the three previous years, in two divisions, the

* See *Journal*, Vol. LXV. p. 603.

† For details of the competition, see *Journal*, November 30th, 1917, p. 23.

‡ See also page 502.

first from March 18th to 25th, and the second from May 6th to 15th. The entries for the March examinations were 10,944, and those for the May examinations 20,191, making a total of 31,135.

The highest number of entries ever reached was in 1914, when they totalled 37,974. In 1915, the first year of the war, they dropped to 32,113, and in 1916 there was a further drop to 25,968; in 1917, however, there was a slight increase to 26,185, and it is satisfactory to notice that this year the numbers have risen to 31,135, showing an advance of 4,950 over the total for 1917.

The entries this year included 443 from prisoners of war or interned men at Ruhleben, Groningen, Chateau d'Oex, and Mürren. Last year the corresponding figure was 279. From London centres 5,091 entries were received; while the remaining 25,196 came from 404 centres throughout the United Kingdom.

A number of entries for examination in Dutch were received from interned men at Groningen. As the Society does not ask these candidates to pay fees, and as there were no others, the Council did not feel justified in incurring the expense of holding an examination in this subject. The circumstances were laid before the Directors of the Standard Bank of South Africa, who generously contributed the sum of £20 to cover the cost of the examination, which has now been duly held.

The liberality of the Worshipful Company of Clothworkers has enabled the Council, as in past years, to offer the usual silver and bronze medals. These medals are very highly valued by the successful candidates, and there can be no doubt that they contribute not a little to maintain the high standard of the examinations.

The results of the First Division of the Examinations, held in March, have already been communicated to the candidates; and those of the May Division will be announced as soon as possible.

The usual detailed report of the examinations will be printed in the *Journal* in the autumn.

XIV.—Viva Voce Examinations in Modern Languages.

Up to the present date 13 examinations in French, German, Spanish, and English for Foreign Students have been held this year in London and Manchester.

At these examinations 234 candidates presented themselves, of whom 181 passed (78 with distinction) and 53 failed.

Other examinations have been arranged in Italian and Russian.

XV.—Conjoint Board of Scientific Societies.

As was stated in the Report of the Council for 1915-16, the Royal Society appointed a Conjoint Board of Scientific Societies, consisting of representatives of twenty-six societies, of whom the Royal Society of Arts was one.

In the two years which have since elapsed, the Board has been organised, the number of the constituent societies has been increased, an executive committee has been appointed, and numerous meetings both of this committee and of the Board itself have been held. Various committees for special purposes have been appointed and have carried through a considerable quantity of work.

The delegates appointed in the first instance to represent the Society were Sir Philip Magnus and Sir Henry Trueman Wood, who still continue in office.

A contribution of ten guineas has been made by the Council this year to the funds of the Board.

XVI.—Journal.

Up to the present year it has always been the custom to print the proceedings at the Wednesday meetings in the *Journal* of the following Friday, and there can be no doubt that the Society has gained great credit from this prompt publication. This session, however, owing to the drastic restrictions on the supply of paper, and its enormously increased cost, it has been found imperative to restrict each issue of the *Journal* to a "sheet" of sixteen pages. This, as a rule, only affords space for the reporting of one meeting, and as, with the Indian and Colonial Sections, there have been thirty-two meetings in twenty-seven weeks, there has necessarily been some delay in publishing the reports. The Council greatly regret this change, which is only temporary and entirely due to war conditions; but they believe that the Fellows generally will appreciate the difficulties under which the *Journal*, like all other periodical publications, is at present being produced, and will make allowances for its reduced size and for the delay in publishing the reports of meetings.

XVII.—New Council.

The Vice-Presidents retiring under the ordinary regulations are Sir George Ranken Askwith, Mr. Arthur James Balfour, Lord Faringdon, Lord Moulton, and Lord Newlands.

In their place the Council recommend Sir William Henry Davison, who has been a Treasurer since 1913; Sir Walter Egerton; Sir Robert Abbott Hadfield, who has been an Ordinary Member of Council since 1916; and Major F. G. Ogilvie and Sir Aston Webb, both of whom have held office on the Council in former years.

The four Ordinary Members of Council retiring are Mr. Alan S. Cole, Sir Robert Abbott Hadfield, Sir Robert William Perks, and Sir Henry Trueman Wood, who is nominated as a Treasurer. In their place the Council recommend Sir Charles Carrick Allom and Dr. M. O. Forster (neither of whom has yet served on the Council), Mr. John Slater, and Professor J. M. Thomson.

XVIII.—Obituary.

The Society sustained a very severe loss by the death of Sir John Wolfe Wolfe-Barry, which took place in January. He served almost continuously on the Council for twenty-four years, and he was Chairman in 1898–1900.

Earl Brassey had been a member of the Society since 1862, and he had served on the Council with few breaks from 1871 to 1882, and again from 1913 to 1915.

Mr. William Charles Knight Clowes was the senior partner of the firm of Messrs. William Clowes and Sons, Ltd., the Society's printers. He joined the Society in 1885, and was twice elected on the Council.

Mr. Samuel Charles Phillips was a recognised authority on the paper, board, and pulp industries, and he read three excellent papers before the Society.

Miss Ruth Morrish Day contributed the notes which appeared for about twelve years in the *Journal* under the title "Arts and Crafts." She was the daughter of the late Lewis Foreman Day, who, up to the time of his death in 1910, was a member of the Council.

Mr. Alfred Gordon Salamon gave a valuable course of Cantor Lectures in 1888 on "Yeast, its Morphology and Culture," and he also received a silver medal for a paper on "The Purity of Beer."

Among other notable Fellows of the Society who have died during the year may be mentioned Mr. Charles Hawkesley, the Hon. Rowland Gibson Hazard, the Hon. Sir Sundra Lal, Sir William Heerlein Lindley, Vice-Admiral William Usborne Moore, Mr. Alfred de Rothschild, Sir Swire Smith, Mr. Thomas Tyrer, and the Earl of Rosse.

XIX.—Finance.

Two changes have been made in the Financial Statement which, in accordance with the usual practice, was published in the *Journal* of June 21st — the first in the dates of the financial year, the second in the form of the Statement.

Hitherto, the Society's financial year has run from June 1st to May 31st, these dates having no doubt been chosen so that the accounts might be brought as nearly as possible up to the date of the Annual Meeting, which is fixed by By-law 39 for the last Wednesday in June. The question of the receipts and expenditure in connection with the examinations has, however, tended more and more, as the amounts involved have increased, to make these dates inconvenient. The receipts came in before May 31st, while the bulk of the expenditure was made after that date, with the result that it was impossible to show the receipts against the expenditure for the same set of examinations, and this militated against the reliability of the Financial Statement in showing the precise financial position of the Society at a given date.

The second change is in the form of the accounts. Instead of the former "Statement of Receipts and Payments" the auditors have prepared an "Income and Expenditure Account" for the year ending December 31st, 1917, and a "Balance-sheet" as on that date.

The Income and Expenditure Account shows that for the year 1917 there was an excess of expenditure over income of £346. This sum is mainly due to the enormously increased costs of printing and paper. On the other hand, as already mentioned,* there has been a very marked rise in the number of new Fellows—373 for the Session, 1917–18, as compared with 164 for 1916–17—while the amount received in Life Compositions this session, £849, is the largest received under this head since 1862.

The Chairman (Mr. Alan A. Campbell Swinton, F.R.S.) moved the adoption of the report. All would agree, he said, that it was very complete and comprehensive. It was a source of great satisfaction that so many new Fellows had joined the Society during the past year, and that the numbers were now increasing instead of diminishing, as was the case at the beginning of the war. It was to be remembered that the Society derived its revenues principally from the subscriptions of the Fellows, and it was

* See page 502.

therefore most important that the numbers should be kept up. There had also been a large increase in the examination entries, which was very satisfactory. They would remember that in consequence of the expenses of the examinations exceeding the receipts from entrance fees, it had recently been necessary to increase the amount of the fees charged to candidates. It was therefore very gratifying to find that, in spite of this small extra charge, the numbers had increased by nearly 5,000 this year. They had had a most interesting series of papers and lectures this session, especially those dealing with the application of science to particular branches of industry. The Indian Section had been as active as usual, and had now entered upon its Jubilee year. The award of the Albert Medal to Sir Richard Glazebrook in recognition of the great work he had accomplished at the National Physical Laboratory had met with general approbation. The question of the finances of the Society had given the Council a certain amount of anxiety, owing to the greatly increased cost of printing and paper, more particularly in connection with the *Journal*. The Council felt, however, that it was the *Journal* which, to a large extent, kept the Society, with its widely-scattered Fellows, together. It was a valuable educational publication, and they considered its continuance most essential, even if the Society did incur a small loss by continuing its issue.

Sir Henry Trueman Wood said it gave him very great pleasure to second the adoption of the report. It would have been a great source of regret to him if, at the end of the first year of his retirement, there had been any falling-off in the activities of the Society. It was therefore with sincere satisfaction he saw how well the work of the Society had been carried on during a very difficult year. Of course, everyone realised that the diminution in the number of Fellows was mainly caused by the war, and it was extremely satisfactory, and reflected great credit upon those responsible for this branch of the Society's work, that there was such a distinct and considerable increase in the number of new Fellows elected this year, for after all that was the truest test of a Society's progress and stability. He looked upon the examinations as a very important part of the Society's work, and the increase in numbers was also quite satisfactory, as it showed that under normal conditions they would again reach the pre-war figures. The Society's finances were in a perfectly sound and satisfactory condition, and in conclusion he wished to express his sincere thanks to the past and present members of the Council for the very liberal and handsome manner in which they had raised the endowment fund to commemorate his Secretaryship of the Society.

Mr. Edward T. Scammell thought attention should be drawn to the good work the Society had done in holding examinations for the interned prisoners at Ruhleben, Groningen, etc. He also remarked on the comparatively small number of Fellows the Society had in Canada and Australasia, and suggested that the Colonial Section might take advantage of the presence in this country of distinguished overseas statesmen to interest them in the economic value of the Society's work, with a view to an increase in the number of Colonial Fellows. Important papers dealing with the economic development of the Empire had been read before the Society, and he thought greater attention might be drawn to the work which the Section had been carrying on for the benefit of the Colonies for so many years.

The Chairman said Mr. Scammell's suggestion would, he was sure, receive the careful consideration of the Council.

The adoption of the report was then agreed to.

The ballot having remained open for half an hour and the scrutineers having reported, the Chairman declared that the following had been elected to fill the several offices. [The names in *italics* are those of Fellows who have not, during the past year, filled the office to which they have been elected.]

President.

H.R.H. The Duke of Connaught and Strathearn, K.G.

Vice-Presidents.

Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.

Lord Blyth.

Sir William Henry Davison, K.B.E., D.L.

Sir (Frederick) William Duke, G.C.I.E., K.C.S.I.

Sir Walter Egerton, K.C.M.G., LL.D.

Peter MacIntyre Evans, M.A.

Sir Robert Abbott Hadfield, D.Sc., D.Met., F.R.S.

Field-Marshal Sir Douglas Haig, K.T., G.C.B., G.C.V.O., K.C.I.E.

Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc.

Lord Islington, P.C., G.C.M.G., D.S.O.

Lord Leverhulme.

Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S.

Sir Philip Magnus, Bt., M.P.

Viscount Northcliffe.

Major-General Sir Desmond D. T. O'Callaghan, R.A., K.C.V.O.

Major Francis Grant Ogilvie, C.B., LL.D.

Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.

Hon. Richard Clere Parsons, M.A.

Sir Boverton Redwood, Bt., D.Sc., F.R.S.E.

Lord Sanderson, G.C.B., K.C.M.G.

Alan A. Campbell Swinton, F.R.S.

Sir Aston Webb, K.C.V.O., C.B., R.A.

ORDINARY MEMBERS OF COUNCIL.

Sir Charles Carrick Allom.

Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.

Edward Dent, M.A.

Martin Onslow Forster, D.Sc., F.R.S.

Major Edward Humphrey Manisty Leggett, R.E., D.S.O.

William Henry Maw, LL.D., M.Inst.C.E.

Sir Francis Taylor Piggott, M.A., LL.M.

John Slater, F.R.I.B.A.

James Swinburne, F.R.S.

Professor John Millar Thomson, LL.D., F.R.S.

John Augustus Voelcker, M.A., Ph.D., F.I.C.

Sir Frank Warner, K.B.E.

TREASURERS.

Carmichael Thomas.

Sir Henry Trueman Wood, M.A.

SECRETARY.

George Kenneth Menzies, M.A.

On the motion of the CHAIRMAN, a vote of thanks to the scrutineers was carried unanimously.

THE CHAIRMAN proposed a cordial vote of thanks to Mr. G. K. Menzies (the Secretary), Mr. S. Digby (the Secretary of the Indian and Colonial Sections), Mr. George Davenport (the Chief Clerk), Mr. J. H. Buchanan (the Accountant), and to the other officers of the Society for their services. He thought the Fellows would agree that this had been a very satisfactory year so far as the Society was concerned, and that this was really due in a great measure to the officers of the Society. Although some of them felt when Sir Henry Wood retired that they would never be so well served again, he felt sure they would agree that the Society had got the next best Secretary it was possible to have.

SIR BOVERTON REDWOOD, Bt., D.Sc., F.R.S.E., had very great pleasure in seconding the vote of thanks. Since the commencement of the war it had been a very difficult matter to discharge duties like those which fell to such a Society as theirs, and the record of work done left nothing to be desired. He cordially endorsed the remarks as to the high standard of excellence of the papers this session, which he said was in no small measure due to the efforts of the Secretary, who, it might truthfully be said, was a worthy successor of Sir Henry Trueman Wood. The other members of the staff were also deserving of their warmest thanks for their loyal services.

THE SECRETARY (Mr. G. K. Menzies) returned thanks for this expression of confidence in himself and in the other officers of the Society. As this was the first opportunity he had had since Sir Henry Wood's retirement he wished to say how much he owed Sir Henry for his training, and with what pleasure he had served under him for the past nine years. The Indian Section had had a very successful session, and the results had certainly justified the amount of labour Mr. Digby had bestowed upon it. The examination staff deserved the credit given to them, and the other members of the staff had earned his gratitude also for the generous way in which they had helped him to carry on the work.

A hearty vote of thanks was accorded to the Chairman (Mr. Alan A. Campbell Swinton) for his services.

The meeting then adjourned.

ENGINEERING NOTES.

Marine-power Progress.—Mr. W. B. Esson, in his paper before the Society of Engineers, stated that it was not until 1862 that the cylindrical boiler met with any degree of success, and he commented on the somewhat remarkable fact that this type now remains in almost universal use, and has been altered only in detail since that early period. The advantage of the water-tube boiler, which is now being manufactured by many firms, is that it can be adapted with more ease to the particular requirement it has to meet than any other boiler of the shell type In marine engines the introduction of the triple-expansion type, working at about 150 lb. pressure, enabled great economies in steam consumption to be effected. In terms of fuel consumption, the modern triple-expansion engine requires from 1·46 lb. to 2 lb. of coal per i.h.p. per hour, and the compound engine from 2 32 lb. to 2 39 lb. The steam turbine for any power over 1,200 h.p. shows an even lower steam consumption. To summarise the results of a large number of tests, it may be said that with 160 lb. pressure and 27 inch vacuum a 3,000 kw. turbo-alternator set will take only 16 lb. of steam per kw. hour. In the 40,000 h.p. turbine recently constructed for the Chicago power-house the steam consumption is guaranteed not to exceed 11·25 lb. per kw. hour with steam at 200 lb. pressure and a superheat of 200° F. As regards geared turbines employed in marine service, the London and South-Western Railway steamers "Hantonia" and "Normannia" show a saving of 40 per cent. over ordinary turbine steamers on the same service.

Tanks in France.—These have been engaged recently in the Aisne sector of operations on the Western front, and have done good service. The French "Tank," like ours, works on caterpillar wheels, but differs in being smaller and having a somewhat greater manœuvring power than our early models. It carries a field gun in addition to several machine guns, and experience has led not only to improvements of structure and armament,

but to a clearer idea of the most advantageous method of using such war-cars.

Irrigation in Mesopotamia.—A correspondent in the *Times* and other papers recently, relates, among other news, that this year, owing to the success of the Euphrates irrigation scheme, the supplies from the Euphrates side will be enormously increased, and the transport of the country will be hard put to it to bring in the grain. During the summer we have been at work on the scheme connected with the Hindieh barrage, designed by Sir William Willcocks and constructed by Sir John Jackson's firm. It was finished before the war, but the Turk neglected to profit by it. The canalisation work connected with it was left incomplete, and the area to be cultivated was never brought under irrigation. The Euphrates divides at Hindieh into two branches—the Shatt-el-Hilleh to the east, and the Shatt-el-Hindieh to the west—and the two channels of the river meet again a few miles above Samawa. Until the nineteenth century the Hilleh branch carried the main canal, but during the last century the bulk of the river has been diverted to the Shatt-el-Hendieh, which was the main channel more than a thousand years ago. The function of the barrage was to provide water for the Hilleh branch, which was silting up, while the bed of the Hindieh branch was scouring out and its water was being wasted. This year nearly a hundred canals on the Hilleh branch, which had fallen into disuse, have been dug out, 300,000 acres have been brought under cultivation, and there is promise of the greatest harvest in the memory of man—possibly the greatest since the days of Nebuchadnezzar.

Tungsten Deposits.—Some of the important deposits of wolframite, a tungsten ore, occur in Asia, and have become of extreme importance since we declared war, as high-speed steel depends for its production on tungsten. The better qualities of high-speed steel contain as much as 18 to 20 per cent. of pure tungsten metal, produced in the form of a fine, dull black powder from the ore. There are several varieties of it, known as (1) wolframite, (2) scheelite, (3) hubnerite, (4) ferberite, all differing in their chemical composition. Wolframite consists of tungsten, iron, manganese, and oxygen, and is frequently found, as in Burma, associated with tin ores. It is a black, or greyish black, extremely heavy mineral, with a specific gravity as high as 7·5. It fuses easily, and is slightly magnetic, an extremely useful attribute, as it enables the wolframite to be separated from the tin ore, when crushed to a powder, by means of magnetic operators. Scheelite consists of tungsten, calcium, and oxygen; in colour it is a great contrast to wolframite, as it is white, yellow, brown, or approximately red; it is not as heavy as wolframite, as the specific gravity is only 6·1, and is practically infusible by any ordinary methods: it can be decomposed by hydrochloric acid; it does not effervesce in acids, and it does not turn a silver coin black, which has been heated and moistened. Ferberite, which consists of tungsten, iron, and oxygen, is the prevailing form of ore found in the United States. Hubnerite consists of tungsten, manganese, and oxygen: it is a brown, brownish red, or black ore; its specific gravity is a very high one, as much as 7·2; it is not readily fused, and can also be decomposed by hydrochloric acid. Another form is known as ferro-tungsten, an alloy of tungsten and iron obtained by removing the oxygen contained in the oxides of the ore. The tungsten ores, according to the *Indian and Eastern Engineer*, are extensively distributed in many Asiatic countries—India, Burma, the Malay States, Japan, Korea, Siam, Indo-China, and the Dutch East Indies.

Tar Oil for Diesel Engines.—The Controller of Munitions Mineral Oil Production has recently appointed a committee to assist him in connection with the subject of fuel oil supplies, and the use of tar oil as fuel in Diesel engines, and of methods to adopt Diesel engines for the use of tar oil. This committee is to be styled The Heavy Oil Engine Fuel Committee. The office is at 19, Cadogan Gardens, S.W. 3. In connection with the above, the *Auto* announces the discovery of a new motor fuel, of which a trial has been made with most favourable results, a motor-car carrying six persons climbing the steepest hills in Paris without the least trouble. The *Auto* explains that this new fuel is produced by the distillation of heavy oils obtained from coal. All the by-products will be available for the preparation of explosives. The new fuel, the newspaper adds, does not foul the cylinders, nor does it leave a residue of carbon.

OBITUARY.

ISAAC SHONE.—Mr. Isaac Shone, M.I.Mech.E., died at his residence in Putney on June 19th, aged eighty-two. He was the inventor of the Shone pneumatic sewage ejector, an early description of which is to be found in a paper on "Sewage Disposal at Wrexham," read before the Society's Annual Sanitary Conference, in 1879, by Lieut.-Colonel Alfred S. Jones, V.C., Assoc.M.Inst.C.E. At that time Mr. Shone lived at Wrexham and was Mayor of the borough. As mentioned by Mr. J. Forrest Brunton, in the paper recently read by him before the Indian Section, the Shone system was installed between 1892 and 1895 at Karachi and has since been extended there with beneficial results, being specially suited to towns so flat that drainage by gravitation is impracticable. The city of Chicago adopted the plan for its drainage works some years ago. Mr. Shone was a Fellow of the Society, having been elected as long ago as 1879.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, JULY 5, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 15th, 1918; Professor William Bateson, M.A., F.R.S., Director of the John Innes Horticultural Institution, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Brain, Henry Richard, London.
Johnson, Hubert, Hull.
Khoo Sian Ewe, Penang, Straits Settlement.
Major, John Lewis, London.
Mhatre, Succaram Vassuded, Bombay.
Parsons, Charles Frederick, London.
Paul, William Hewitt, Birkenhead.
Poulter, Captain Herbert William, Baghdad.
Saklatwalla, B.D., B.Sc., Dr.Ing., Pennsylvania, U.S.A.
Smith, J. Hatchar, F.R.I.B.A., London.
Symington, William, Bickley, Kent.
Wolseley, William Augustus, London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Cleminson, H. M., London.
Dutton, Reginald John Garfield, Skegness.
Howell, Alderman Thomas H., Newport, Monmouth.
Librarian, National Library of Ireland (Department of Agriculture and Technical Instruction), Dublin.
Martineau, William, Wallingford.
Oury, Libert, London.
Taylor, W. Howson, West Smethwick.

The paper read was—

TIMBER INDUSTRY.

By Percy Groom, M.A., D.Sc., F.L.S.,
Professor of Technology of Woods and Fibres, Imperial College of Science and Technology.

This paper will mainly deal with the extent to which technical science can aid, or has aided, in promoting the timber industry in this country and the utilisation of the timber resources of the British Empire. Although it is obvious that practical details in trade will constitute limiting factors of the extent to which organised application of technical knowledge can be of immediate commercial and Imperial service, little consideration will be given to obvious practical questions such as the impending revision of the relations between employer and employee; the wisdom of improved organisation of the timber trade along lines that are in the interests of the trade, the nation, and the Empire; and the effect of tariff reform.

The special qualities of timber that render it all-important in daily life may perhaps be best understood if we consider the demands made on wood in the living tree, which is exposed to various vicissitudes during its prolonged existence. The wood at the base of a tree-trunk has to withstand tons of pressure per square inch, while the trunk has to resist the bending action associated with its columnar form and the shearing tendency of its boughs. The trunk and branches have to resist shock caused by gusts of winds acting on a large head of foliage. Yet the young wood of the twigs or outer parts of the trunk must possess a certain degree of extensibility and toughness, as opposed to brittleness, so that they can endure change of shape under shock. Since one essential function of the wood is to conduct rapidly water to the leaves, wood must necessarily contain water-channels, and therefore be an excavated not a solid material. And since the water conveyed contains substances in solution, wood is capable of impregnation by watery solutions of dyes and preservatives. Remembering the great heights attained by certain tree-trunks, and the immense load of branches, it is necessary that wood in the tree be relatively light in weight when compared with its strength and stiffness. Finally, it is evident that wood in the tree must possess a certain degree of durability.

These various qualities essential to wood, in order to make possible the existence of a tree, render timber a material having unique properties as regards strength, elasticity, extensibility, and above all confer upon it a general superiority to metals as regards comparative weight and strength. The feeble powers possessed by wood of conducting heat, the relative ease with

which it is worked, and the great variety of timbers available, enhance its value and add range to the variety of uses to which it can be put as a structural material. Moreover, in certain situations, or when appropriately treated, wood is far more durable than iron; and can be subjected to processes by which it successfully withstands temperatures at which iron flows away as a molten liquid. Consequently as a *structural* material wood subserves purposes too familiar and numerous for enumeration.

When disintegrated it yields *fibres* that provide paper and cordage; while as a *chemical* complex wood is a fuel, and is the source of substances as diverse as charcoal, alcohols, acetone, formalin, artificial silk, turpentine, dyes, scents, and drugs.

New uses for wood are constantly being discovered and old uses being increased, so that with the advance of civilisation the consumption of timber per head of population steadily rises, despite its replacement for certain purposes by other materials such as iron and ferro-concrete. Hence in this country and the British Empire generally we know that there will be an ever-widening demand for timber.

The amount of wood used by this country may be estimated by a consideration of the imports in 1913.

In 1913 the values of the imports of timber into the United Kingdom were :—

	£
Softwood (conifer) logs, sawn, planed, etc.	22,800,000
,, ,, pit-timber	4,400,000
,, ,, wood-pulp	5,425,000
Total	£32,625,000
Hardwood, oak-logs	1,700,000
,, wood manufactures	4,600,000
,, teak, mahogany, furniture, etc.	3,800,000
	10,100,000
Softwoods and hardwoods. Total	£42,725,000

In addition, there was consumed a large amount of wood grown in the United Kingdom.

The largest item is represented by *softwoods*, which grow in the north-temperate regions, and are actually exported thence to tropical and southern countries. In the British Empire there is therefore only one great source of supply, namely, Canada. The supplies of softwoods are steadily decreasing in amount and receding in accessibility. The depletion of supply is particularly marked and serious in reference to constructional softwood of large dimensions and good quality. At present Douglas Fir (British Columbian pine), some pitch-pine in the United States, and some Scots pine in the recesses of Russia, represent such large timber. When these stocks have vanished they will probably never be replaced, because in modern forestry operations conifers in artificial forests are felled at the age of seventy to eighty years, as they then yield the optimum return.

It is therefore evident that the price of softwoods will continue to rise, and the more so with the increasing demands made by the growing southern nations in Australia, South Africa, and elsewhere.

What steps are to be taken to alleviate the threatened situation? In answer, four possibilities suggest themselves :—

1. Increased production of softwoods in this country, and the British Empire generally, by *afforestation.*
2. Partial substitution of hardwoods grown in British Colonies and Dominions for softwoods imported from foreign countries.
3. Maximum avoidance of loss and waste.
4. Further economy in the usage of timber.

Dealing first with the last possibility, the question arises: Is this country extravagant in its consumption of wood? The answer must be in the negative, since the subjoined table proves that the annual consumption per head of population is less than that of any other Great Power, with the solitary and small exception of Italy.

APPROXIMATE ANNUAL CONSUMPTION OF WOOD IN CUBIC FEET PER HEAD OF POPULATION.

United States	260
Canada	192
Russia	63
Austria-Hungary	57
Germany	36·6
France	24·6
United Kingdom	14
Italy	13

Although the consumption of wood in this country is not extravagant, I shall show later in this paper that not inconsiderable economy is possible.

The question of *afforestation* in the United Kingdom has been repeatedly considered by Governments. The scheme appealed rather to statesmen than to politicians, and as a commercial proposition promised only a modest return at a distant date. Recent experience has, however, introduced a broader outlook, which recognises the direct and indirect effects of forestry upon agriculture, rural re-population,

and the defence of the country, so that sanction has been given to a scheme in Great Britain. Years ago I endeavoured to interest the War Office in a scheme of combining an increase in the Army with the initiation of afforestation that should be carried out by a staff mainly recruited from men who had served in the regular Army or were auxiliaries in the Army. It is to be hoped that some such plan, taking cognisance of the existence of the Royal Air Force, will be considered for adoption throughout the British Empire.

The success of any measures, including afforestation, designed to improve conditions in this country as regards the timber industry, will depend finally upon the extent to which the pertinent scientific and technical knowledge is acquired and applied. The remainder of this paper will therefore be devoted to a survey of the fundamental facts and principles that have been learnt through research, and to some mention of problems calling for solution.

The chief, but not exclusive, problem of afforestation in this country is the successful production of coniferous timbers or softwoods. Great Britain with its temperate island climate is well suited for the growth of conifers, and taking into consideration its ranges of temperature, altitude, and soil, I am of opinion that the British Isles are better suited than any other country in Europe for the cultivation of a wide range of conifers. The main question, however, is not the successful growth of the tree but the successful production of timber of proper quality; the former does not necessarily involve the latter. Yet we do know that good coniferous timber can be grown in this country. Years ago, by means of mechanical tests at the Imperial College, it was discovered that timber of Scots pine grown even in the south of England is suitable for paving the streets; while last year mechanical tests proved that not only in the south of England, but also in the highlands of Scotland the Scots pine can yield slow-grown timber that is equal to the highest demands ever made on wood, namely, use in vital parts of aeroplanes.

Now not only do the timbers of different kinds of trees differ in their qualities, but the timber of one and the same species of tree varies according to the conditions under which it is grown. Therefore, if timber of the best quality is to be produced, it is necessary to be able quantitatively to estimate the mechanical values of different samples, and to analyse the conditions under which these have grown, so that in forestry operations the correct treatment may be adopted in connection with each species of tree. Some of the valuable results obtained in this connection by the researches of botanists, foresters, and mechanical engineers, may now be considered.

Timber is not strictly a material, but is an elaborately designed structure, consisting of solid wood-substance excavated so as to form a framework. The elementary structural units of wood are hollow: their solid walls and sometimes their cavities contain water; the portions of their cavities unoccupied by water are mainly filled with air. When a piece of wood is completely dried its weight may be regarded as wholly due to the solid framework of wood-substance (though this is not absolutely correct). Inasmuch as the specific gravity of the wood-substance of all kinds of timbers investigated is approximately the same (viz. about 1·55 or 1·56), it follows that the so-called specific gravity, or the weight per cubic foot, of absolutely dry timber is a sufficiently correct indication of the amount of wood-substance in it. A "heavy" timber has much wood-substance, a light timber has only little wood-substance. Hence it follows that the strength, stiffness, hardness, and heating power of timbers tend to be proportional to their respective specific gravities, so long as they contain the same percentages of water. This tendency is at a maximum when different samples of one and the same kind of timber are in question.

In the case of the most important of all coniferous timbers, the Scots pine, the specific gravity and compressive strength of the heaviest wood are more than three times those of the lightest wood. If comparison be made of the timber of this tree grown on similar soils and with similar treatment, but in different climates, changes in structure of the wood are revealed to the naked eye. As the climate becomes colder growth is slower and the annual growth-rings of the wood are narrower, but this diminution of the thickness of the rings takes place more at the expense of the soft light spring-wood than of the heavier harder red summer- (autumn-) wood. Hence the narrow-ringed wood is heavier and stronger. When, however, the climate becomes too severe—as in regions nearing the Arctic zone—the attenuation of the growth-rings continues but the wood is lighter in weight and weaker; such is the red deal exported from the White Sea. A knowledge of these facts rendered possible during the present war the correct anticipation of the occurrence in the

highlands of Scotland of slow-grown, light Scots pine, eminently suited for use in aeroplanes. Variations in the soil and in the light to which Scots pine is exposed cause corresponding changes in the structure and properties of the wood. One example of the comparative effects of knowledge and ignorance in these matters may be cited in reference to the present war. Germany having made thousands of mechanical tests and observations on the structure of Scots pine growing in various forests of that country, was able instantly to secure rich supplies of this wood of exactly the quality required for aeroplanes. In this country, until the present war began, we did not know the mechanical values of any kind of timber whatsoever growing in the United Kingdom, still less did we know the values for the different varieties of one timber, nor where these varieties were to be found: we were compelled to find and then test the woods that might be suitable.

Results similar to those obtained in regard to Scots pine hold good for Norway spruce (*Picea excelsa*), as is proved by the subjoined values obtained by Professor Janka on this wood grown in Austria:—

Width of annual ring (in millimetres).	Specific gravity($\times$100).		Compression parallel to the grain (crushing stress in kilograms per square centimetre).	
	Seasoned.	Absolutely Dry.	Seasoned.	Absolutely Dry.
·5—1	44·9	41·7	397	743
1—1·5	44·3	41·3	395	729
1 5—2	43·1	40·2	386	708
2—2·5	41·9	38·9	364	666
2·5—3	41·3	38·4	353	647
3—3·5	39·9	37	339	622
3·5—4	40·2	37·2	342	619
4—4·5	39·1	36	314	581
4·5—5	40·2	36·8	308	554
Above 5.	38·1	34·9	306	510

By way of contrast to the softwoods discussed, hardwoods of the type of the oak and ash may be considered. In these, as the growth is more rapid, the increased width of the annual rings is often mainly caused by disproportionate additions to the hard, heavy, fibrous summer-wood produced outside the soft, weak, porous spring-wood. In the case of the oak there is probably a limit to this tendency, as towards the south of Europe oak timber, though wide-ringed, is slightly softer than that grown in our own climate. The weakness of narrow-ringed porous ash-timber is familiar to all practical men, especially in connection with those trees that have grown slowly under the influence of excessive shade.

In timbers of this type there is a decline in weight and strength when the annual rings are of the same thickness, but there is a wider zone of porous wood (due to a larger number of series of pores). Monsieur Thil found, for instance, in oak, where each annual ring was half a centimetre in thickness, that the tensile strengths of three samples, showing respectively 1, 2 to 3, and 3 to 4 series of pores in the spring zone, were 17·1, 13·6, and 12·7 kilograms per square millimetre.

The tendency for opposite effects to be induced in pine and ash timbers by widening or narrowing of the annual rings explains one practical matter in connection with parts of aeroplanes in which the wood is used in the form of thin laminae or is spindled out; the pine must not be wide-ringed, whereas the ash must not be narrow-ringed. Another practical lesson in this connection may at once be learnt by anyone observing the variety of qualities or grades of blocks of Scots pine paving streets in London. He will then note that in certain parts of London the use of inappropriate grades of this wood causes great economic loss and unnecessary public inconvenience.

Mechanical tests on timbers, apart from providing one of the bases for sound forestry, are of value in yielding the necessary information as to the minimum dimensions required by constructional wood used for specific purposes. They thus render possible the utmost economy and the substitution of one wood for another.

Afforestation in Great Britain can yield considerable supplies of softwoods only many years hence; consequently the provision of substitutes in the form of hardwoods grown specially in British tropical Colonies would be of great economic importance if practicable. There are, however, both technical and commercial difficulties in the way.

The extensive use of softwoods as structural material is due to several sets of factors. First, coniferous trees grow in the north-temperate regions, forming forests that are pure or contain large numbers of the same species of tree. Softwoods are thus accessible and can be obtained cheaply: this is especially true of Baltic softwoods. These coniferous timbers are usually easy and cheap to work, often display high strength-values when compared with their weights ("specific gravities"), tend to shrink less than hardwoods, and generally are more easily and rapidly seasoned than are the latter,

while as sources of fibre and paper they yield a very high percentage of fibre.

On the other hand the hardwoods abounding in the vast forests of the British tropical and southern Dominions and Colonies are generally more distant, for even the West African Colonies are farther away than the Baltic. Moreover, the hardwood trees in them grow together in mingled confusion, hundreds of different species growing side by side. Consequently definite kinds of hardwoods are less accessible than are softwoods.

Yet many of the hardwoods have certain advantages on their side. In moist tropical countries their growth is generally much more rapid than is that of the northern conifers, and there is no present demand for certain of them, indeed in some cases they represent obstructions that have to be removed and destroyed. Considering the amount of loss involved in the artificial destruction of tropical trees, the utilisation of such waste wood forms a problem of first-class economic import. Investigations will show that numbers of these inferior neglected woods can be utilised either as substitutes for softwoods of the better quality, or as fibre-yielding material to be used in the manufacture of paper, or chemically to yield alcohol, and so forth.

As regards hardwoods of better quality, and often greater weight, some may be employed as substitutes for hardwoods—such as oak, teak, and mahogany—that are partly imported from non-British countries, or may be more vigorously exploited in foreign lands. But to accomplish these aims full information as to the mechanical and working properties of such woods is required. We have very little detailed information as to the mechanical and other properties of such timbers. Yet investigations conducted during the present war have demonstrated the suitability for use in aeroplanes of certain mahoganies and other hardwoods from British West Africa, Papua, Queensland, British East Africa, and India, and of certain softwoods from New Zealand and British East Africa.

These considerations lead once more to the study of the structure of timbers, whose significance in affording guidance to the qualities and uses of woods has already been indicated. Research into the structure of timbers is also necessary as a means of rendering possible the critical *identification*. Such identification is needed in order that a person shall secure exactly the kind of wood that he requires. At present the commercial nomenclature of timbers is in confusion. For instance, in various parts of Australia the same names are applied to different timbers, and different names to the same timber: such practice militates against the sale of these woods in this country, for it may be said that every kind of wood has certain uses for which it is fitted better than any other. To select another example; a number of kinds of wood varying widely in colour, structure and properties, are sold in this country under the name of West African mahogany. Apart from the disappointment experienced frequently by purchasers, and the consequent tendency for West African mahogany to be discredited, this particular case is not devoid of national significance. I believe that the most motley array of such so-called mahoganies before the war came from the German Colony, Cameroon, which did not export anything like the same quantities as did the British and French Colonies. The natural result would be that the wrong attachment of the name of mahogany to the German spurious mahoganies would inflate their price, while lowering the price of British and French genuine woods. In importing the latter Germany would profit doubly.

So far no reference has been made to the great part played by water present in wood. By exhaustive tests it has been proved that the strength, stiffness, and hardness (when measured by indentation), of one and the same piece of wood vary inversely as the amount of water contained in the wood-substance itself. The table already given shows that in the case of spruce the absolutely dry wood has far greater resistance to crushing than has the merely seasoned wood. The pliability and ductility of wood, on the contrary, increases with rise in the water-contents, and greatly so if this be accompanied by rise in temperature. Wet-steamed wood can, therefore, be compressed to form railroad keys or bent to yield furniture; whereas very dry wood permits of only slight deformation, and in this sense is brittle.

So far two reasons exist in favour of drying wood before use—decrease of weight, and improvement of mechanical qualities; and these are accompanied by a third, which is associated with the changes of shape and dimensions of wood as it absorbs or emits water.

When once all the water has been removed from the cavities of the wood (and even before this when drying is relatively rapid) wood shrinks steadily as it continues to dry. Shrinkage is far the least along the grain; while across the

grain it tends to be much greater circumferentially than radially. Hence, during drying, a piece of timber would undergo considerable distortion were it not that wood possesses ductility. As a matter of fact such distortion in the form of warping or twisting often does take place in bastard-cut boards or planks when the process of drying is carried on too rapidly, and the warping may be accompanied or replaced by splitting in a radial plane.

This differential shrinkage along and across the grain partially accounts for the practice of cutting up highly figured wood and knotty burr-wood into thin and relatively small veneers. Somewhat akin to this veneering process is that of the manufacture of *ply-woods*. In three-ply wood, for instance, as the outer sheets or plies have their grain in a direction at right angles to that of the middle sheet or ply, the outer and middle plies tend to check each other's tendency to shrink or increase in surface. Moreover, since wood is much stronger along than across the grain the three-ply possesses a combination of transverse and longitudinal strength impossible in a single piece of the thickness equal to that of the three-ply. In ply-woods the plies glued together may number from three up to seventeen or perhaps more, and may be composed of a single kind or several kinds of wood. The manufacture and use of ply-wood is only in its infancy, and is bound to increase greatly, as, apart from the merits already mentioned, it renders possible the structural utilisation of cheap and relatively weak woods, which, if desired, can easily be impregnated with substances that render them decorative, fire-proof, or resistant to decay. While ply-wood and the woods yielding them are practically exclusively imported from foreign countries, there certainly exist in the various countries of the British Empire timbers that are not being utilised at all or to best advantage but yet are eminently fitted for use in ply form. But our knowledge on the technology of ply-wood requires amplification by research on a whole series of problems concerning the woods and adhesives suitable.

To return to the question of the relations subsisting between wood and water, it is known that a piece of wood continues to dry until at least its surface is in moisture-equilibrium with the water-vapour of the surrounding air. Thereafter it will absorb or exhale water according as the air becomes drier or moister, so that it is always shrinking or swelling. By limiting these interchanges of moisture, coatings of varnish, paint, and the like reduce such movements; but up to the present no one has solved the profoundly important problem of rendering wood absolutely impervious to moisture.

The preceding remarks provide sufficient justification for the *seasoning of timber*. Such seasoning was originally, and is still usually, accomplished by storing the felled wood in the open air, with or without a roof to screen it from rain and direct sunlight. This so-called "natural seasoning," being dependent upon climate, is prolonged and irregular, sometimes in abeyance and at other times too rapid. The prolonged storage not only ties up capital, but also involves loss of wood through decay or boring insects; while its occasionally excessive rapidity introduces loss due to case-hardening, warping, or splitting.

The early discovery that seasoning is the consequence of a process of desiccation led to the drying of wood by artificial heat. Primitive methods caused unduly rapid superficial desiccation and consequent development of defects (splits, brittleness and so forth). Improvements, including the regulation of temperature, moisture of the air, and air-currents in a drying chamber or kiln, have rendered possible the balanced drying of the inner and outer parts of the timber, and have culminated in modern methods by which wood subjected to the severest strains that it ever encounters, namely in aeroplanes, can be reliably seasoned in kilns. These results have been attained solely through the most careful research, involving the use of instruments registering the changes in temperature and moisture in kiln and wood, and including investigation into the causes of such defects as brittleness, case-hardening, collapse, explosive splits, and so forth. Not all woods are artificially seasoned with equal facility. For instance, the oaks among hardwoods and swamp cypress among softwoods require special and careful treatment; on the contrary, when compared with hardwoods, softwoods are more easily and rapidly seasoned, and can be safely exposed to higher temperatures, as their structure is less complex and their shrinkage generally less. Hence experiments are required to reveal the best, including most economic, treatment of timbers of different kinds and different dimensions. Even when wood and dimensions are the same the most economic treatment will depend on the use to which the wood is to be put, and the urgency of the demand; for instance walnut used merely for panelling can be exposed to much more rapid and drastic

seasoning at high temperatures than if it be intended for use in the propellers of aeroplanes.

Such investigations will certainly repay the expenditure of time and money, not alone in the resultant saving of time but also in the economy of timber. As regards the former, by kiln-drying the time of seasoning is reduced from years to months, and from months to days, or, for certain purposes, to hours. While, as regards economy of timber, Tiemann calculates that in the United States the losses of timber due to natural seasoning are five and more than twelve per cent. respectively in softwoods and hardwoods, and that these can be reduced to 2 per cent. In view of the fact that in certain types of kiln-drying waste steam may be used, the economic significance of these facts is doubly clear.

One method of introducing heat and moisture into a kiln is to supply steam. Drastic steaming at high temperatures permanently weakens wood, even it be relatively brief. On the other hand, prolonged steaming or "stewing" of wood in a confined space improves the qualities of woods in certain directions, in that it decreases their tendencies to warp and sometimes renders them more decorative by changing their colours; for instance, beech is thus induced to become somewhat mahogany-like in tint and in resistance to warping. This off-shoot of artificial seasoning provides an additional line of inquiry leading to the improvement in the qualities of inferior woods, especially from our tropical Colonies.

The seasoning of wood has yet one more important bearing on the economy of timber: it increases the resistance to decay. Decay or rot, in at least the overwhelming majority of cases, is caused by wood-destroying fungi, which demand for their development a certain amount of water.

The protection of wood from decay is a matter of great national importance. In our shallow and damp coal-mines, where the air is warm and moist, wood-destroying fungi are often so abundant and so active that timber is rendered useless in a few weeks or months. In 1913 the value of the imports of pit-timber into this country was nearly £4½ million sterling. An American investigator calculated that in the United States, if 40 per cent. of the pit-wood were treated with antiseptics, the annual saving in that country would be more than 50 million cubic feet of timber. I myself have seen a coal-mine in which the untreated pit-props had to be replaced in four to twelve weeks; whereas creosoted props side by side with them had already lasted for eight years. The neglect of adequate protection of wood from decay in this country is emphasised by the fact that I can secure no approximate estimates of the loss in pits, in buildings, fences and posts, or ships. The resultant loss must amount to millions of pounds annually, and much of that loss could be economically prevented.

Two methods, namely sanitation and antisepsis, offer themselves as means of decreasing or preventing the decay of wood.

As in pathological problems generally, and especially in epidemics, sanitation is in the end the cheapest method; but it demands a knowledge of the life-histories and conditions of activity of the organisms doing the damage. A few facts and examples may serve to illustrate the type of research that is urgently called for.

Fungi, which spread by means of their threads or microscopic spores, can be found growing in any house or damp coal-mine. Some of these are practically harmless, others actively destroy wood; it is therefore necessary to identify the fungi present, and to investigate their action in wood. After that the first practical problem in sanitation is to determine the source of the noxious forms, which may come from the forest, timber-yards, builders' yards, ships, or coal-mines, or elsewhere. The neglect of the elements of sanitation may be noted in builders' yards, where infected wood removed from houses is stored side by side with fresh timber and sometimes ready for incorporation into a new building. In a very large timber yard in London I have seen the fructification and spawn of the most virulent dry-rot fungus lying almost in contact with immense stacks of softwoods.

The fungi responsible for dry rot and decay generally vary in their demands for moisture. Some demand quite moist wood, and can readily be exterminated by ventilation and protection of the wood from wet; yet a few species, when once established, can manufacture water and thereby attack the driest wood. Some are readily killed by heat and cannot thrive at relatively high temperatures, others are more resistant to heat.

Again, certain species send their threads into the wood and spread internally at a slow pace, keeping at a distance from the surface. Cases due to this type of fungus are easily dealt with by removing the attacked piece of wood, whereas other species not only penetrate the wood but produce sheets or cords that rapidly

swoop over the surface of the wood, grow over and penetrate walls, and so transmit the infection through a complete building or roadway in a coal-pit.

Some species can attack only one kind or class of timbers, so that sanitation may take the form of avoiding the use of these. Other species can destroy woods varying from pine to oak and even teak.

This last consideration brings forward the question of the natural durability of timbers, upon which experiments are essential from the direct practical point of view and because the investigation of the relative immunity of certain species may afford a clue to a cheap and simple method of increasing the durability of woods that normally possess little.

As an accessory to or a substitute for sanitation, timber may be protected by the use of antiseptics such as zinc chloride, creosote and its derivatives, and various other inorganic and organic substances. These differ from one another in their fungicidal efficiency, some being completely effective against all fungi, others being (in practicable concentrations) lethal only to certain kinds of fungi. Moreover, the durability conferred depends upon the depth to which the antiseptic penetrates. Hence the precise process (whether painting or injection under pressure) and the precise fungicide to be used will depend partly upon the length of time that the timber has to last. These will also depend upon the situation of the timber: creosote with its powerful scent and discolouring qualities cannot be used in dwellings; whereas zinc chloride is not eminently suited for superficial coatings out in the open as it readily washes off. The discovery of cheap antiseptics suitable for various situations is a line of research of such fundamental importance as to be worthy of patient chemical and mycological investigation.

Time forbids my entering upon the less familiar but not unimportant question of protecting wood on land against boring insects, and of timber in sea-water (in piles, docks, etc.) against boring marine animals.

Just as the antiseptic treatment of wood renders possible the replacement of valuable durable timbers by cheap perishable ones, so likewise does the *fire-proofing* of wood subserve economy by permitting thin pieces of inferior wood to be substituted for thick pieces of more costly wood; specifications demanding that the doors of buildings shall be made of teak of great thickness are therefore extravagant, even though decorative. Investigations have rendered possible the fire-proofing of wood to such an extent that even thin three-ply can be made to resist for minutes or hours a temperature of 3000° Fahrenheit. The process of satisfactory fire-proofing is, however, not a cheap one, as the cheaper substances used are apt to wash out, to attack metals, and even favour the development of decay-inducing fungi. A problem of vital importance to builders, and even to the Empire, is the discovery of a cheap solution that shall simultaneously protect wood against decay and fire, and shall be suitable for use in dwellings.

Another method of improving woods, and especially those of inferior quality, is that of changing their colours and thereby improving their decorative value. By this means unmarketable colonial woods may be rendered of use. Such changes may be induced by steam, by chemical treatment with vapours or solutions, by treatment with dyes, or finally by exposing the wood to the action of fungi or bacteria. Except as regards the production of fumed oak by ammonia vapour, this branch of industry has been neglected in this country, which imports such stained woods as grey sycamore, artificial ebony (for piano-keys, knife-handles, and so forth).

As an illustrative case, reference may be made to grey sycamore, which is obtained from ordinary white sycamore by means of simple and cheap chemical treatment. Yet for years white sycamore was exported to Paris and Hamburg for treatment, and re-imported into England at an increase of price perhaps fifty times the true cost of the process. Great Britain does, however, export one unique type of coloured wood, brown oak, which, owing to its richness of tint, is much more valuable than the ordinary British oak. At the Imperial College it was discovered that the brown colour is induced by a fungus, and that by growing the latter upon ordinary oak this is converted into the brown wood. It would doubtless be possible to devise a method by which this exceedingly profitable conversion could be conducted on a commercial scale.

The chemical utilisation of wood forms too wide a subject to be dealt with except by allusion. As a means of using up waste wood (sawdust, shavings, slabs) in the sawmill, or waste trees in forests of the Colonies, mention may be made of the destructive distillation of wood, which thus becomes a source of methyl alcohol, formalin, acetic acid, acetone, and charcoal. In countries having feeble supplies

of coal this same process can be made to yield illumination and power. Other problems concern the most economical manner of using waste wood directly as a fuel.

In connection with several lines of investigation, mention has been made of the utilisation of waste wood, and in order to illustrate the fact that this alone represents a problem of national importance I will mention that in this country there is one single wood-using establishment in which the normal annual loss or wastage of timber represents a sum approaching £20,000.

For the purpose of demonstrating what the British Empire has done and is doing in the way of forwarding technical knowledge relating to timbers, I will compare its activities with those of two other great Powers, the United States and Germany.

Although France produced the first model investigations on the mechanical properties of wood, Germany in recent times has done a large volume of excellent work and correlated the results with the structure of timbers concerned. Along the two lines she has been ably seconded by Austria, and these two partners have conducted minute and detailed research on timber-structure from the point of view of identification. To Germany more than any other country we owe our modern knowledge on the fungi inducing decay in timber, and on modern antiseptics suited for combating them. Germany, together with Austria, has largely contributed to the development of the technical art of changing the colours of woods by chemical means and by dyes. Her work on the utilisation of wood as a fibre material, as fuel, and by destructive distillation has given to her the leading place in these fields.

Germany has, in addition to her forestry schools, various institutes from which emanate the results of researches in the various branches of the subject. And the State has founded, staffed and equipped, an institution whose sole function is to investigate the problems of the decay of timber and its prevention.

Germany thus spends thousands of pounds annually on timber investigation. She also promotes the use of her colonial timbers by this means, and by describing or referring to them even in small text-books.

The United States has produced many valuable results on the mechanical properties of North American timbers, and on technico-practical questions concerning American woods as sources of fibres and of chemical bodies. Her workers have also published much detailed original information on the structure and identification of the indigenous timbers. While in one branch, that of artificial seasoning of wood in kilns, the United States leads the world in original investigation and practical invention.

Apart from possessing some forestry schools, the United States has one institution specially founded for the investigation of timber problems, namely, the Forest Products Laboratory, at Madison. I believe that the annual sum paid for researches in this laboratory exceeds £40,000. This laboratory works in close touch with men engaged in the timber trade. And the timber trade journals published in the United States give, by the very nature of their articles, sufficiently clear evidence of the intimacy of the relations between wood industries and technical science.

Great Britain doubtless was handicapped by the lack of any great forests that should stimulate research of the highest type on the mechanical qualities of timbers. First-class original work up to modern standard has never been produced in this country on this branch; the work done has been narrow in scope, because done by engineers, who even to-day are profoundly ignorant of the basic facts on the subject of wood-structure. The sole comprehensive modern researches on the mechanical properties of wood conducted in the British Empire emanate from Australia. In regard to the structure of timber this country has contributed little, except fragments concerning colonial woods. But in India Mr. Gamble has produced a great work on the macroscopic structure of Indian woods. Although England at the outset led the way in providing antiseptics and means of injecting them into timbers, her original scientific activity in this direction ceased decades ago; while as regards the investigation of the fungi causing decay in timber our Empire has done practically nothing.

Altogether, famous as this country has been in the past from the practical standpoint as regards timber, she has been a nonentity as a contributor to the scientific technology of wood. The time has past when it is safe to continue such a policy.

In the United Kingdom, although there are some incipient schools of forestry, and there is a professor of the technology of woods at the Imperial College, the State neither maintains any technical authority on timber in its employ

nor devotes any sum to research on the subject. The timber industries likewise have no technical consultants nor do they subsidise research. Hence, where the Governments of the United States and Germany spend annually thousands of pounds on timber-research conducted by specialists, our Government spends not a penny, though the wood imports amount in value to more than forty million pounds sterling annually. The Forest Research Institute in India, and Forest Products Laboratory in Canada, represent the official provision made by the British Empire for the investigations on woods coming from forests that are larger in extent and variety than those governed by any other State in the world, and whose value must be reckoned in hundreds of millions of pounds.

But there are signs of awakening as regards research. The awakening is Imperial, not merely national: and this is of vital importance because this country and the remainder of the British Empire should be linked together in policy as regards the great timber problem of the future, and therefore linked together in attacking the problems whose solutions will dictate that policy and will indicate the best method of utilising our common timber resources. In this country and in Australia Departments of Scientific and Industrial Research have arisen, and it is to be hoped that the great trades will also take part in this forward movement, for the greatest advances can be achieved solely by the co-operation of the State, the trade, and the technical specialist —and this is especially true of the great timber industry.

DISCUSSION.

THE CHAIRMAN (Professor William Bateson, F.R.S.) said the paper provided a great many subjects for thought on a great variety of topics. The point that had impressed him most was the apparent hopelessness of trying to keep up with the supply of timber required by the life of modern civilisation. It appeared that we were in the same position with regard to timber as we were with regard to coal and rock oil, namely, that we were living on our capital and that, however we managed the existing supply, we should not have enough to meet the needs of the present population. In the case of wood used for paper, for example, destruction was going on very quickly, even though the Governments of the various countries concerned were doing their best to promote production. He had himself seen the lamentable picture the landscape in Australia presented, where one could travel for hundreds and even thousands of miles through country consisting almost entirely of dead trees, magnificent trees which had been killed by the early settlers in the hope that they might have one sheep to every three acres on an average. It would take something like a thousand years to replace those trees. A great deal could be done to promote the production of timber, but he would like to know whether the author thought it would ever be possible to produce the quantity of wood that the population of the earth at present required.

MR. A. L. HOWARD thought the paper was a sufficient answer to the gentleman who, when Professor Groom read a paper before the Aeronautical Society in that room, said that scientific research was of no use with regard to timber, and that what was wanted was the advice of practical men who understood timber. The paper contained a great deal of food for reflection for the practical timber expert. With regard to the quality of the timber grown in England, until the previous autumn he did not know that timber grown in the south of England was not only as good as but considerably better than some timber imported from the Baltic. He had seen Scots pine grown in the south of England which, in freedom from knots and sap, was superior to a great proportion of the timber that had come from the Baltic. In that connection he might mention that, whereas the price allowed to be paid for the foreign article at the present time approached 8*s*. per foot cube, the price which was allowed to be paid for the British-grown product, whether it was of the highest possible quality or of the lowest possible quality, did not reach 4*s*., or half that of the foreign article. He thought that was a continuation of the policy adopted in the past, which had led to the deplorable results witnessed at the present day. Twenty years ago the Arboricultural Society appointed a Rates Committee, of which he was a member, and he found that Germany carried foreign timber inside her borders at a rate which was many time greater per foot than the rate at which she carried her home-grown product. Germany also gave a premium to everybody who would use the home-grown product, and she made it difficult to use the foreign product. The Committee found that in England it cost as much to bring timber from Liverpool to London by rail as it cost to bring it from a thousand miles in the interior of America and across the Atlantic into London. The second point in the paper which he thought was particularly worthy of remark was the number of tests which Germany had made in regard to the quality of timber. He assumed that the author's remarks in that connection applied only to Scots pine, because in this country we knew the mechanical values of many of our timbers other than the Scots pine. With regard to the question of the name of the timber imported from the West Coast of Africa and sold under the name of "mahogany," and the harm that has been done to this country and the benefit that had ensued to Germany thereby, he did not think the author's explanation was quite correct. He was afraid the real reason why the wrong names were given to timbers was because of the want of

scientific research and knowledge, and of any attempt to bring to the front the proper way of dealing with woods and their names, and because of the looseness of our laws in connection with the matter. For instance, for many years past large quantities of so-called Austrian oak had been supplied in this country which consisted of other kinds of oak, and yet the timber had been accepted and used. Then again, certain teak was called "Borneo teak," although he thought it was a fact that there was not and never had been any teak in Borneo. While teak possessed an essential oil which was preservative to itself and to everything with which it came into contact, the wood which was called teak and sold as teak possessed an essential oil which was harmful to itself and to everything with which it came into contact. The same point applied in connection with many other woods. For instance, it had been found impossible to sell the sweet gum of America under the name of "gum," and it had been called successively satin walnut, hazel pine, and Californian gum. The mixing of woods was generally to be traced to tradesmen, who gained a benefit by so doing, and there were apparently no laws or societies or associations to protect the users. With regard to the question of sending timber to be coloured in Paris and Hamburg, the British public would not buy coloured woods very readily; the demand for them in this country was very limited and uncertain, and it was therefore not worth while establishing plant to any extent. The cost of freight to and from Paris was very small, and the process of dyeing adopted there was very beautifully performed. If there had been a greater demand in this country for coloured woods, no doubt that demand would have been met by the establishment of plant on a larger scale. He did not agree with the author's remarks about the economy practised by this country in the use of timber, because he thought we were the most extravagant people in the use of timber that the world had ever seen. If a comparison was to be made of the consumption of wood in different countries, the varying circumstances and necessities of those countries must be taken into account. For instance, the population of the United States as compared with its area was very different from that of Great Britain, and many farmers in America and Canada built their houses of wood. A comparison could not be fairly made between the amount of timber such men required and the amount needed by men living in brick houses in London. The extravagance in the use of timber in England, especially since the war began, was positively criminal, and he was afraid the Government was the greatest offender. A contract had recently been put out by the Government for field telegraph poles about 8 feet or 12 feet long and $1\frac{1}{2}$ or $1\frac{3}{4}$ inches in diameter, and the contract provided that a sum of about £7,000 should be expended on Oregon pine at something exceeding 8*s*. per foot cube for those poles. Before the war clean, straight-grained Oregon pine could be obtained for about 1*s*. 6*d*. or 1*s*. 10*d*. a foot, and then perhaps it was the best timber that could be used, but why should 8*s*. per foot cube be paid now for Oregon pine for field telegraph poles when those poles could be just as well made of white spruce or Scots pine or larch, for which the Government would not allow anyone to pay more than 10*d*. per foot? It must also be remembered that that Oregon pine at 8*s*. per foot cube was of doubtful quality, because, if that was not so, it would have been worth 24*s*. per foot cube for aeroplane work. Then, again, he had seen maulheads made of beautiful timber brought from abroad at a cost of about 12*s*. or 14*s*. per foot cube, when British elm would have done perfectly well. Lastly, what about the policy of a Government that established an enormous Timber Department for the purpose of economy in supplying timber? Such a department might be necessary, but it certainly was not economical. He did not think any Government Department in this country was ever carried on on economical lines.

Mr. Hugh Davies said he wished, as a member of the Department of Scientific and Industrial Research, to make some defence against Mr. Howard's criticism that Government Departments were not economical. The Department of Scientific and Industrial Research was concerned with economy in the use of timber, and hoped shortly to be in a position to do a great deal in assisting the public to economise in that direction. Lack of economy in regard to timber did not always arise from pure waste of timber, but from failure to use the material to the greatest advantage in view of its particular properties. For example, when timber was used for building or engineering work it was customary to provide a factor of safety of about 10, as compared with factors of safety of 3 or 4 with other materials. At first sight it might seem that there was no alternative to such a course, in view of the results of tests made upon timber, but recent investigations with regard to the lamination of timber and to the use of timber in the form of plywood showed that there might be ways of using timber which would enable the factor of safety to be reduced to 5. That would mean the reduction of our expenditure on timber by something like one half, which would be a very substantial economy.

Mr. William Woodward, F.R.I.B.A., speaking from the point of view of an architect, said he had been very much impressed by the paper, and by the excellent practical remarks of Mr. Howard. With regard to the teak mentioned by Mr. Howard, he did not know whether the author could say why there was a very obnoxious smell from certain teak. He knew of a case where a city office had been fitted up with teak, at very great expense, and it all had to be removed owing to its unpleasant smell. Mr. Howard had also spoken of Austrian oak, and

in that connection he might say that architects had for many years been in the habit of using Austrian oak because unfortunately they could not use English oak for ornamental purposes. Architects did not know whether so-called Austrian oak came from Austria or from some other country, but they had used it because of its practicability for ornamental purposes. For many years past they had not been able to obtain the Spanish mahogany that they formerly specified for ornamental purposes, and one could only find real Spanish mahogany when one visited certain fine old-fashioned hotels in some parts of England. With regard to the fuming of wood mentioned by the author, architects only knew of the fuming of oak because of its appearance, but whether fuming was injurious to the wood or not he did not know. The fire-proofing of wood was of course a very important matter, but he could not say whether fire-proof material had withstood fire. The question of dry rot was of very great importance to architects and to their clients, and the means of preventing dry rot had occupied the attention of the Royal Institute of British Architects for many years. It was sometimes said that dry rot could be prevented by efficient ventilation. When it ensued, however, the fungus spread very rapidly, and in order to preserve the timber from further inroads of dry rot various expedients had been employed. If the author could tell the Institute of British Architects how they could, in the construction of a new building, prevent future dry rot, he would do a very great service to architects and to their clients. With regard to seasoning, that was sometimes induced by artificial means, which he had always understood to be very deleterious. He believed that seasoning by heat killed the wood and led to premature decay, and that it ought to be entirely avoided. Formerly timber yards were often seen where the timber was drying with spaces between it in a natural way, and although that method was not adopted so frequently at the present time he believed it was the proper way to season timber.

Dr. J. A. Voelcker said the paper illustrated a story to which the people of this country had become pretty well accustomed in other industries besides the timber industry—the old story of ignorance and neglect, and the need of further scientific research, and the encouragement of that research by the Government. It appeared that this country had made a start in one or two branches, but that other countries had got ahead of us, and one very potent reason for that had been the want of scientific research, and of Government encouragement to that research. He was glad to think that in the matter of forestry there was a sign of some change in this country. He wished to put in a plea for the landowner, because he did not think that in the past the landowner had been altogether to blame. He remembered that about thirty years ago he stayed with a friend who had an interest in a colliery in the Midlands, and who had a quantity of wood on his own property quite near the colliery. That friend told him that it cost him more to cut up his wood and use it for pit-props for his colliery than it did to get the pit-props from Norway and Sweden; therefore there was no reason for him to encourage the growth of timber. If a landowner did anything in the way of forestry future generations would reap the benefit of it, and the chance of his seeing any return for his money was not very great. He thought a change was about to take place, however, as was indicated by the shows of the various agricultural societies of this country. The shows of the Royal Agricultural Society indicated that a great and increasing interest was being taken in the subject of forestry, and many points of interest, some of which had been mentioned in the paper, were being brought out in connection with those shows. The author had given concrete instances of the need for scientific research in the direction in which it might be rightly exercised. He had spoken, for instance, of fungi, and had said that fungi were very much like bacteria—they were not necessarily all bad, and some were even beneficial to timber. Two important subjects for research were the preservation of wood by antiseptics and the rendering of it fireproof.

The Earl of Powis said he would like to know what Mr. Woodward meant by the statement that it was impossible to use British oak for ornamental purposes. Personally, if he wished to use oak for ornamental purposes he would certainly specify British oak. He knew that for many years past a great many architects had been opposed to using British timbers, and had stated in their specifications that foreign timbers were to be employed, but he thought that was due, to a great extent, to the difficulty of obtaining exactly the quality of timber that was required at the moment and not to the fact that it was not growing in the country. He thought British timber ought to be encouraged a great deal more, and architects were the people who could best give that encouragement.

Mr. William Woodward, F.R.I.B.A., said that the reason why he did not specify the use of English oak for ornamental purposes was that, although he had always used it for posts, gates, and other things outside the building, he had found that it was quite unfitted for ornamental panelling inside the building, because of its splits or fractures. English oak did not preserve its evenness of texture in the way that Austrian and other oaks did.

The Earl of Powis said that in his own house, where nothing but British oak that had been seasoned for fifteen years was used for the panelling, not one single crack had appeared in any of that oak.

The Chairman, in proposing a vote of thanks to the author for his interesting paper, asked whether the teak which the author mentioned as suffering

from fungi was real teak or not. He was under the impression that the oil to which the smell of teak was no doubt due acted as a strong antiseptic against fungi.

The resolution was carried unanimously.

PROFESSOR GROOM, in reply, said that, with regard to the quantity of wood in the world, his reason for particularly urging the use of tropical woods where possible, especially in reference to fibre-making, was that with every rise in temperature the rapidity of chemical action increased, and, therefore, as that held good with regard to trees, if people wished to employ wood economically they should grow it in the moist tropics of Africa and America. He had never considered the question of whether timber could be grown in sufficient quantities to meet the demand, but it was a most interesting problem. He thought it could be done very easily at the present time. The reason why he mentioned teak as subject to dry rot was because it was such a resistant wood, and yet when the fungus *merulius* had obtained a start in soft wood it could attack and destroy good teak. With regard to the disagreeable aroma of teak, he did not know the cause, but every practical man knew that when teak had been sawn up it often smelt very unpleasantly, and it was also known that in Siam teak logs were sometimes stored for weeks or months in extremely unsavoury mud close to the native villages. He cordially agreed with Lord Powis's opinion as to the quality of British oak and its superiority to every other type of oak from a decorative point of view, although it was harder to work and more liable to split. Anyone who went to the Court of Criminal Appeal and examined the panelling there, which was made of British oak, would agree that it was the finest modern panelling one could find anywhere.

The meeting then terminated.

MR. A. L. HOWARD writes:—It is fortunate that the Earl of Powis dealt with Mr. Woodward's statement that it was impossible to use British oak for ornamental work, partly because it could not be obtained and partly on account of its liability to split, etc. Had I not felt that I had already spoken at too great length, I should have wished to refer to this subject on account of its national importance. For the past twenty years many timber firms have followed the practice, which I think I may claim to have originated, of manufacturing and storing very large quantities of the highest possible quality British oak in the way required to overcome the objections raised by Mr. Woodward, which were originally due to the ignorance and apathy of the British timber industry. In the opinion of many, no foreign oak—either Austrian or any other—could for a moment compare in beauty, durability, or value with the British. We realise this when we stand before the exquisite old panelling in some ancient building such as Haddon Hall in Derbyshire, Marks Hall, Coggleshall, in Essex, or the superb room taken from a palace at Bromley-by-Bow, now in the Victoria and Albert Museum. For variety of grain, sense of solidity, but more than all for richness and warmth of the right tone of colour, what is there to compare with it? Strange it is in an age when the revival of design and architecture has made such strides that so few have realised the rare beauty of British oak work. In the past our supplies have been more appreciated in America than at home, but there still have been many fine specimens of work, especially of later years, and I beg I may be excused if I venture to catalogue some of these with which I have been acquainted, where I have personally selected the timber in some cases with my own hands. They are as follows:—

The Thistle Chapel at St. Giles', Edinburgh, designed by Sir Robert Lorimer, and built by Mr. N. Grieve. The British oak used in this building was over fifty years sawn and sticked and was grown in Essex.

Liverpool Cathedral, designed by Mr. A. Gilbert Scott, also supplied from the same wood as above.

The dining-room of a house at Hyde Park, the work executed by Holland & Hannen, being a reduced copy of Brewer's Hall.

The new buildings of the Law Courts, executed by T. H. Kingerlee & Sons, Oxford.

The sub-committee room and other rooms at Lloyd's Registry, designed by Collcutt & Hamp and built by J. Mowlem & Co. The sub-committee room is one of the most beautiful examples of British oak work, and was furnished from timber grown in Essex and Northampton.

Also by the same Architects, the offices of the P. & O. Co. in Leadenhall Street, and Sir Thomas Sutherland's house in the country. This gentleman, with the architects and others, has probably contributed to the advantage of his country and the history of the future by insisting (on some occasions not without opposition from some quarters) that the P. & O. Co.'s steamers should be trimmed with English oak.

Mr. G. T. Wills' house at Sunningdale, built by J. Bentley & Sons, Waltham Abbey. The timber used here was mostly grown on Lord Chesham's estate at Latimer.

Mr. T. E. Collcutt's house at Totteridge, Herts, possesses a superb hall and room.

Mr. Alfred B. Smith, The Crossways, Totteridge, Herts, has a similar hall and staircase.

The Lynch House, Totteridge, Herts, possesses a hall and staircase made from oak entirely grown in the hedgerows at Totteridge Park.

Highwood, Highwood Hill, has a fine hall and staircase in British oak executed by J. Simpson & Son.

Much of the above work in British oak, and a good deal more, was made by John Ayton, originally of

Dunmow, in Essex, who is an artist in this work, but who, I hope, would not be offended at being called a village carpenter. I mention this here only because of the prevailing idea that it is too difficult to carry out decorative work in British oak.

At Newberries, Radlett, occupied by Mr. George Miller, there is a handsome British oak hall executed by J. Simpson & Son.

A superb building in Bedfordshire was lately erected by Holland & Hannen for Mr. Clutterbuck in all British oak.

I could mention a great many more, but will content myself by referring only to Armament Buildings, Whitehall. The Government specified that this work was to be executed in Austrian oak, after the war had broken out in 1914. Fortunately the authorities altered it to British, and two beautiful rooms were provided by H. C. Cleaver, Ltd., of Wembley. A brass tablet is displayed on the panelling giving the botanical variety and place of growth of the oak used.

It might not be out of place here to refer to a note in the Blue-book of the Westminster Hall roof:—

a. The timber should be open grown oak in park situations or grown as coppice and standard.

b. The soil in which the timber is grown should be known, and should be a stiff retentive loam.

c. The species should be the *pedunculata*: sessile or durmast oak should not be used.

e. The timber should be at least two to three years fallen before converted. . . . Timber merchants, as a rule, can give no information as to the species of oak from which the timber has been cut. In addition they have no note of the soil on which it has been grown, nor would they appear to have very definite records as to the time of felling. Their general attitude is: "Here is my supply of oak, I have got a large market for it, so you can take it at my price or leave it."

folio 43. Report to First Commissioner of H.M. Works, *re* Westminster Hall.

I do not agree with any of these remarks. The greatest known authority on the subject of British oak, and the man who probably had the most extensive practical experience, says:—

"It is the prevailing opinion that the wood of the *Quercus Robur pedunculata* is the best in quality, and that the *Q. Robur sessiliflora* is slightly inferior to it, but while concurring generally in this opinion, I feel bound to admit that, during a long experience in working them, I have not been able to discover any important difference between the two varieties."

folio 43/44. Timber and Timber Trees, Laslett.

Having studied this question closely for many years, I agree with Laslett that it is impossible to distinguish between the wood of the two botanical varieties. The utmost that can possibly be said is that the product of *Q. sessiliflora* is on the whole somewhat milder in the grain, but as by far the principal supply of the country consists of *Q. pedunculata* it cannot matter much, as no work to any extent could be carried out if only authentic supplies of *Q. sessiliflora* had to be used. I am also of opinion that it is quite immaterial to know where the timber has come from, or of what the botanical variety consists, as those who know timber can judge at a glance of the suitability or otherwise of its quality without further inquiry. The really important question is how it is cut, manufactured and stored. Here, again, I find myself at variance with the Westminster Hall Blue-book. I am persuaded that for the trees or logs to remain for any period before conversion is bad, and the longer they remain the worse it is: trees under such circumstances are open to the attack of all kinds of fungi and boring insects. Large cracks and defects result from the uneven action of shrinkage, where insects can penetrate and the fungi thrive. It is only after many years perhaps, when the timber has been placed in position in the building, that the damage becomes apparent. The waste in conversion is largely increased, and no real seasoning of the timber can take place. Trees should therefore be sawn into planks and boards immediately after felling, and the manner of conversion should be studied in accordance with the circumstances and the probable requirements of the timber. Among the many disadvantages from which British-grown timber has suffered in the past, not the least has been the utter lack of thought and trouble in felling, conversion and subsequent handling. In other countries the absolute necessity for fostering the trade has resulted in better practices, and in no case is this better illustrated than in the forests from whence so-called "Austrian" oak has been produced.

OBITUARY.

Edward Cookworthy Robins, F.S.A., F.R.I.BA.—Mr. Robins, who died on June 18th, at the age of eighty-seven, became a member of the Society in 1870, and served on the Council from 1887 to 1890, when ill-health compelled his retirement from all work, public and private. As a member of the Court of the Vintners' Company he took an active part in the movement for the promotion of technical education in the City of London, the result of which was the establishment of the City and Guilds Institute. In 1882 he read a paper before the Society on English and Foreign Technical Education. In the same year he was appointed by the Council Architect to the Society, and in that capacity took charge of the renovations and improvements made in the meeting-room and the library, including the ventilation of the former. He had a considerable practice as an architect from 1858 to 1890. Among his executed works were Weeley Church, Essex, the Camden High School for Girls, the Bedford Grammar School, and the Merchant Venturers' School, Bristol. He was one of the pioneers of modern sanitation, took great interest in, and designed the fittings for, science schools and laboratories, and published a book on the subject.

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CONTENTS.

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Royal Society of Arts

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Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, JULY 12, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

CHAIRMANSHIP OF COUNCIL.

On Monday, the 8th inst., at their first meeting in the new session, the Council re-elected Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman for the ensuing year.

PROCEEDINGS OF THE SOCIETY.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 29th, 1918; SIR WILLIAM A. TILDEN, D.Sc., LL.D., F.R.S., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Basden, Duncan Frederick, London.
Forbes, David MacHattie, Hawaii.
Highfield, John Somerville, M.Inst.C.E., M.I.E.E., London.
Liversidge, Engineer-Captain Edward William, R.N., Bermuda.
Prosser, John, Greenwich.
Shipley, Rev. Samuel Paul, F.R.Hist.S., Oakham.
Taylor, Charles Wardrope, South Shields.
Vyle, Gilbert Christopher, Birmingham.
Wisnom, Engineer-Commander William McKee, R.N. (retired), Cardross.
Wordingham, Charles Henry, M.Inst.C.E., M.I.E.E., Redhill.

The following candidates were balloted for and duly elected Fellows of the Society:—

Barouch, L., London.
Brown, George, Greenock.
Clapperton, George, Oxford.
Claus, William Henry, Alderley Edge.
Fryer, Frederick George, M.I.Mech.E., York.
Pugh, Ralph John, London.
Talbot, Benjamin, Middlesbrough.
Taylor, Alderman Herbert, J.P., Eaglescliffe, Co. Durham.

The paper read was—

ORGANIC CHEMISTRY IN RELATION TO INDUSTRY.

By DR. M. O. FORSTER, F.R.S.,
Treasurer of the Chemical Society; a Director of British Dyes, Ltd.

Prominent among the industries which have been pursued with unflagging activity since the outbreak of the world-war is that of criticising our fellow-countrymen. Instruction of other people in the art of reforming the conduct of their affairs has always appeared an attractive exercise to the average Englishman, and probably each one of us must plead guilty to having practised it at one time or another. It seems to be a simple task, and in performing it we are plentifully endowed with that wisdom which comes after the event; moreover, in reviewing the shortcomings of our victims we are frequently ignorant of the difficulties which beset their path, and of the time and energy which have been absorbed in surmounting the common physical and psychological obstacles which present themselves in the daily routine. In a word, we are too much inclined to judge men in the light of how we should wish them to behave, rather than to accept them as experience of life has taught us that they do behave. It is not my purpose in this paper to swell the volume of fault-finding, but I do desire to entreat once more for the recognition of organic chemistry as a vital factor in the successful prosecution of British industrial enterprise.

If there is one lesson which, more than any other, has been taught by the discipline of war, it is the need of being self-contained. In regard to food-supply the U-boats have shown themselves to be the most energetic missionaries of this gospel, and do not require assistance in their adventure. Board of Trade statistics will show to what extent the textile industry, except in regard to wool and jute, is dependent

upon foreign countries for its cotton, hemp, silk, flax and wood-pulp. All these raw materials resemble one another in being almost literally raw materials, that is to say, natural products upon which but little labour has been expended besides that required for cultivation and collection, followed by transport to manufacturing centres; but the textile industry depends also upon a raw material which is to this extent peculiar, that it includes numerous products of highly skilled workmanship, arising from an auxiliary industry which is more complicated than any other. You will immediately recognise this raw material as comprising the vast range of synthetic dyes, and it is because of this exceptional relation to the textile industry that aniline-colour manufacture has come to be called a key-industry, controlling, as it does, an industrial output approximating in value to one hundred times its own.

It must be remembered that aniline-colour manufacture is only one branch—although a very important one—of the organic chemical industry. The production of explosives, illuminating and fuel oils, natural and artificial remedies for disease, photographic materials, margarine, soap, rubber, perfumes, artificial silk, and celluloid, whether inflammable or non-inflammable, is intimately connected with the principles and practice of organic chemistry, whilst the production of spirituous liquors, dairy produce, meat extracts and cereal foods has undergone marked improvement in consequence of applying this branch of knowledge to its control. The general public, however, so far from realising their debt to organic chemistry, would be puzzled to find a definition for it, and this they owe to the tardiness with which even the highest educational authorities have recognised it as a distinct branch of science. Until quite recently the colleges and universities have placed organic chemistry in a secondary position, marked by leaving instruction in the subject to a subordinate member of the staff. Happily this deficiency is gradually being made good. Manchester, indeed, has had a professor of organic chemistry since the days of Schorlemmer, but a similar post was not established at University College, London, until 1902. The example was followed by Leeds in 1904, Oxford in 1913, the Imperial College of Science and Technology in 1914, and Liverpool University in 1915. The Universities of Aberdeen, Belfast, Birmingham, Bristol, Dublin, Durham, Edinburgh, Glasgow, St. Andrews and Sheffield still possess only one professor of chemistry apiece, however, and it is left to chance, assisted by the appointments committee of the respective body, to determine whether a new occupant of the chair displays organic or inorganic proclivities.

When contrasted with the corresponding situation in Germany, this record is one which goes far towards explaining our admitted inferiority in this branch of science. *Minerva* for 1913–14 discloses the fact that the twenty-one German universities were provided with 108 professors of chemistry, an additional forty-nine representing the senior chemical staff of the nine technical high-schools. In Great Britain and Ireland there were eighteen universities with thirty-five professors of chemistry, nine further educational institutions having amongst them twelve such professors, making a total of forty-seven, compared with the German total of 157. In proportion to the difference in the population of the two countries, it might be stated that Germany has only twice as many professors of the subject as are to be found here, but this would give a false impression of the facts. It is less illusory to consider the position from another standpoint, namely, that a population half as large again as that of the United Kingdom has been influenced by the instruction and inspiration derived from a body of teachers three times the number of our own; from this it follows that, even assuming equality of receptivity as between the students, and of capacity as regards the teachers, the output of German chemical talent may be estimated at between four and five times that of this country per annum. Remembering that this disproportionate effort has been operating during a period of many years, we cannot be astonished that the present relative position of the two countries in the matter of chemical achievement has been reached.

Quite apart from the material fact that, when applied to the numerous industrial processes which it underlies, organic chemistry has been highly remunerative, I claim that it offers one of the most attractive available agencies for cultivating the human intelligence, for the man who devotes his life to this branch of scientific study may incidentally satisfy most forms of intellectual craving. Since this claim has been obscured in the past, it may be worth while to review the evidence which supports it.

The first mental demand of which we become aware is for romance, and as in some

respects we nearly all remain children for most of our lives, this need survives until death. Carefully studied, the history of synthetic dye manufacture, which has been more than anything responsible for the development of organic chemistry, is highly romantic. The accidental discovery of the first one by a lad of eighteen, who forthwith laid the foundation of a profitable commercial enterprise; the discovery of magenta in France, also fortuitous; the dazzling prosperity of Simpson, Maule and Nicholson; the gloomy failure of their successors, Brooke, Simpson and Spiller; the discovery of the diazo-reaction by a peasant-student; the twenty-four hours' interval between the Caro, Graebe and Liebermann patent in Germany and the Perkin patent in England, for the manufacture of alizarin; the consequent elimination of madder from among the products of agriculture; the persistent German efforts to elucidate the constitution of indigo and to base thereon a process for its commercial synthesis; the complete and profitable triumph of these; the consequent decay in the cultivation of natural indigo; the also consequent development of the contact-process for sulphuric acid manufacture; the improvements in the production and storage of chlorine, and the diabolical misuse of this material in 1915, are some of the salient incidents in the life of a great industry. A study of these, and of many more which cannot here be considered, a calculation of the part which each has played, and a just appreciation of the men connected with them, would furnish material for one of the most absorbing and fascinating histories of triumph and tragedy yet remaining to be written.

Methodical habits are not so widely diffused as we might wish, but happily there exists in many people a desire to be precise and orderly. Systematic organic chemistry is the crystallisation of orderliness. When the study of carbon compounds first began to attract attention one hundred years ago, scarcely fifty of these materials were known to chemists, and among them there appeared no order, no relationship. At the present time more than 200,000 are known, their number increases each day, and all are capable of being relegated to some clearly-defined group by the simple process of reviewing their origin and their properties. The number of such groups is comparatively small, but the relationships between them are well understood, and it is a mere statement of fact that there is more order among the 200,000 than there was among the original fifty.

An appeal is also made by organic chemistry to the creative instinct and to the imagination which, in some form or other, are found implanted in the mind of every civilised man. One hundred years' study of carbon compounds has revealed a bewildering variety of processes by which this element may be brought into combination, principally with hydrogen, oxygen and nitrogen, to a minor extent with chlorine, bromine, iodine, sulphur or phosphorus, and indirectly with almost every other elemental form of matter. These processes of combination are the weapons in the hand of the chemist by means of which he is able to bring about new atomic arrangements, leading to compounds which have never been built up before, or which have been constructed only under the guiding influence of living animal or vegetable organisms. In this manner the existing 200,000 organic compounds have been brought to light, and the possibilities being by no means yet exhausted, the combinations remaining to be achieved continue to attract the synthetic-minded chemist to the task of realising them; in this exercise imagination plays a most important part by devising the frame-work of theory upon which the practical details of the science are laid.

Two examples of this principle may be usefully quoted. Prior to 1865, a confusing number of materials derived from the coal-tar hydrocarbon benzene had been accumulated, devoid of any system by which the relationship of the substances to one another could be explained. The structure of most compounds not derived from benzene or similar hydrocarbons could be represented on paper by diagrams in which the carbon atoms appeared as links in a chain, these chains being short or long according to the number of carbon atoms involved in their construction. Sometimes the chains were straight, and sometimes they were branched, but they were always open at both ends, and the compounds they represent have come to be known as "open-chain" compounds, or, because the earlier members of the series were derived from fats, as fatty compounds. On these lines, however, there was no theory to explain the constitution of benzene derivatives until, in 1865, a very simple hypothesis suggested itself to the German chemist Kekulé, who had noticed that in these derivatives there were never fewer than six atoms of carbon. He imagined these six atoms as forming links in a chain which differed from former chains in being closed at both ends

to produce a ring, or "closed chain": thus benzene itself, with six carbon atoms each combined with an atom of hydrogen, has come to be represented symbolically by a regular hexagon. The result of this exercise of imagination was magical. All those accumulated materials derived from benzene, the relationship of which had been unintelligible hitherto, arranged themselves in orderly compartments, and the two great classes of organic compounds came to be more strictly defined as fatty or open-chain, and benzenoid or ring compounds. Progress has demanded certain slight modifications of these groups, but it is not an exaggeration to say Kekulé's theory of benzene constitution gave to organic chemistry a new lease of life, since it not only established order where formerly was chaos, but it furnished both foundation and incentive for many of the most fruitful chemical investigations of later days.

The second great example which illustrates the use of imagination in the study of organic chemistry is to be found in the theory of the asymmetric carbon atom, usually associated with the name of the Dutch chemist van't Hoff in the year 1874, but owing even more to the celebrated Pasteur, the founder of bacteriology. Here again the effect has been to clear away an accumulation of puzzles and obscurities, to lay the foundation for more stable classification, and to furnish a mental stimulus for fresh investigations : it lifted the chemical mind out of two dimensions into three.

Whilst the creative instinct, in its intellectual aspect, leads to exercise of the imagination, its physical expression is found in the development of manipulative skill or craftsmanship, and this craving, strong in most of us, may be fully satisfied by the pursuit of chemistry. A modern laboratory needs to be equipped with an immense variety of apparatus and materials, the use of which demands patience and ingenuity if waste is to be avoided and security maintained. The adaptation of existing apparatus to fresh requirements and the designing of novel implements to overcome new obstacles often call into play the inventive faculty, and gradually develop in the chemical practitioner a craftsmanship peculiar to his art. In this connection it is noteworthy that chemistry, although a branch of science, resembles the other branches, excepting mathematics, in retaining many characteristics of an art.

Nevertheless, for those who are mathematically inclined, chemistry offers many attractions. The extension of boundaries leads to conflict, and it has already been found that the borderlines of scientific study have a tendency to become interlaced. This has happened with chemistry and physics, and the interdependence of these two branches has become so complete that the study of physical chemistry has acquired the dignity of a separate branch, in which the exercise of mathematical science may find full play. Another application of the mathematical faculty may be made to the study of crystals, which abound in great variety among both organic and inorganic forms of matter.

Finally, it will be acknowledged by all those who have tasted the joys of chemical research and have contributed, in however modest a degree, to the sum of chemical facts, that independent investigation of the numerous problems which unfold themselves to the chemist offers great opportunities for the development of character. Veracity, perseverance, attention to detail, observation, judgment and patience are some of the qualities which the practice of chemistry should lead us to acquire, and however short of these virtues we may fall as human individuals, it would probably be admitted by every research chemist that the delights and disappointments of his work have assisted him philosophically to

"... meet with Triumph and Disaster,
And treat those two impostors just the same."

This acquirement is doubly valuable at the present moment, when for most of us life has become a silent conspiracy of broken hearts endeavouring to face a new world with whatever courage and cheerfulness can be mustered.

Hence it is justifiable to claim for chemistry that it offers innumerable exercises for the mind and is consequently an admirable training-agent for the young, besides being the source of continuous mental pleasure to the mature intelligence. Moreover, its application is not confined to the purely intellectual—as distinguished from the human—aspect of life. The development of chemical research in the direction of synthetic drugs has been remarkable in the production of numerous valuable remedies, and consequently the chemist has proved a useful ally to the physician and surgeon in the relief of human suffering. In following this line of work another branch of the main subject has incidentally been opened, namely, bio-chemistry, a province in which

biology and chemistry join hands to their mutual benefit. The cultivation of this field has brought out very clearly the fact that organic chemical processes underlie such important functions as animal digestion and assimilation of food, the curative treatment of disease by anti-toxins, and the various changes by which plants absorb carbonic acid from the air and minerals from the soil, thus enabling them to build up wood-cellulose, starch, sugar, and india-rubber; alkaloids such as nicotine, cocaine, and quinine; colouring-matters such as alizarin and indigo; poisons such as morphine and strychnine; spices such as pepper, mustard, vanilla and cinnamon; and finally, the long list of perfumes which delight the senses, such as camphor, rose, peppermint, jasmine, clove, lemon-grass, and violet.

It is one of the many regrettable features of human life that nothing approaching full advantage can be taken of the whole sum of human experience. Up to a certain point, however, the mistakes of one group of people can be used as danger-signals or sign-posts for a succeeding one, and although the war, when viewed as a calamity which has visited this generation, is an incalculable horror, its lessons and its discipline, if properly read and assimilated, may be turned to unceasing benefit by succeeding generations. It is the duty of those among us who may survive this visitation, or who, by the gallantry and self-sacrifice of our younger fellow-countrymen and allies, have been permitted to follow our respective callings in relative peace and comfort, to give our minds whole-heartedly to the task of so focussing these lessons that the benefit obtainable from them may be secured to our successors.

Searching, then, for a fundamental principle which would appear to explain our shortcomings in the past, we find that the great weakness of our national method has been, speaking broadly, neglect to study the inner qualities of the materials to be manipulated, both physical and psychological. The British engineering and textile industries have gained their foremost position amongst the great undertakings of the world by the outstanding skill of the workers engaged therein, supported by the daring and enterprise of the controlling heads. These qualifications, however admirable in themselves, will not alone enable us to maintain our position in the future. They must be fortified by an intimate knowledge of the chemical and metallurgical properties of the raw material, because it is only by such knowledge that crude products can be utilised with the finest and most enduring results, and their applications extended to ultimate possibilities. In making this claim I am not suggesting that everyone engaged in the textile industry should be a professional chemist or that engineers should be trained metallurgists. That is neither necessary nor desirable; but it is desirable that the practitioners of these two industries should have been provided with a bare outline of the respective branches of science underlying their occupation, and it is necessary that the directive heads should have access to highly-trained chemists and metallurgists for frequent consultation.

Reluctance to make use of college-trained men has been partly due to the discovery by some employers that a college training is incomplete and one-sided, but reflection should show that this is quite inevitable within the limits of time by which the average student is fettered. It is not possible to impart the kind of knowledge which can immediately be utilised to improve any but the worst works' processes, because an interval must elapse before a graduate can adjust his mind to the new environment. The factory differs fundamentally from the university in several aspects, important among which is the condition that whilst the chief aim of the university is to impart, classify and extend knowledge, often without much regard for expense, the principal purpose of the factory is to apply it as profitably as possible. Due allowance for this basic distinction has not been made by employers in the past, with a consequence that they have experienced disappointment and shown impatience with the human material provided by the colleges.

I do not pretend that the faults have lain on one side only. It has been claimed by manufacturers that the college graduate is too academic to be of practical value, and that professors are remote beings who float in an attenuated medium of their own hypotheses, ignoring the plain facts and requirements of industrial operations. In support of this contention illustrations could easily be quoted from public knowledge, but on the other hand it is not reasonable to expect men whose principal work lies in one field, namely, the extension and distribution of knowledge for its own sake, gracefully and authoritatively to exert themselves with equal success in surroundings novel and uncharted. Moreover, it should be remembered by business men that the professorial attitude, often regarded by

them as dictatorial and overbearing, arises largely from the nature of the professorial calling—namely, imparting knowledge to comparative beginners in their subject. A man whose chief activities are engaged in the daily transference of his own information to the less mature minds of the students in his class must be something of a superman if his mental attitude is not affected thereby, and this factor, associated with the habit of untrammelled and enthusiastic discussion of scientific problems with his fellow-investigators, may go far to explain that peculiar state of mind to which the business man takes exception, and which he sometimes labels intellectual arrogance.

As in solving all problems arising from human limitations, it is imagination which is needed, a readiness on both sides to make allowance for another standpoint; a determination, equally on both sides, to eliminate mere personal prejudices of outlook, combined with a joint resolution to concentrate in utilising the contribution which each side may be capable of making to the general advancement. To use a felicitous expression by Dr. George Pernet, there must be added to the *entente cordiale* an *entente cérébrale* between the practitioners of science and industry, which will enable them to penetrate each other's psychology, and in this process to cut the barbed wire as delicately as possible. This may sound like a counsel of perfection, as indeed it is, but it is not incapable of partial achievement provided both groups are deeply in earnest, realise the issues involved, and are not under any illusions as to the cost of failure.

Before this ideal can be fully attained, however, very radical alterations will need to be made in our system of education, which should be directed primarily towards giving every boy and girl an opportunity to reveal any natural gift which may lie hidden, and in the case of those who possess distinct mental aptitude, launching them on the road to develop it as fully as possible. It is probably true that genius will always come to light in spite of the most discouraging circumstances, but there is very little genius in the world compared with the huge aggregate of moderate capability which, like the mineral resources of an imperfectly explored country, has not yet been brought to the surface. To paraphrase a homely proverb, we must take care of the talents and the genius will take care of itself.

Had the doctrine of equal opportunity as between classics and science been pursued in the past, this generation of Englishmen would now be reaping two great benefits. In the first place the number of trained scientific workers in this country would have been much larger, and secondly, the general public, not actively engaged in the study of natural science, would have been much more accessible to the possibilities of scientific discovery. At present there is no perspective in such matters. A piquant illustration of the gulf between fact and fancy in the public mind was furnished last January by a prominent daily newspaper, which produced a mild sensation even in these sensational days by publishing a flamboyant and thrilling narrative, heavily headlined "GERMAN DYE SECRETS CAPTURED." From this it appeared that two enterprising gentlemen from the textile industry had commissioned a chemist to visit Switzerland and report on the value of "257 recipes" which had been spirited out of the Badische Anilin- und Soda-Fabrik. It was no "week in lovely Lucerne" for the chemist, who was represented as having been drugged, assaulted and thrown in the gutter; but the 257 recipes came through in safety and a Foreign Office bag. Newspaper interviews and correspondence flourished for some days afterwards—and very properly too, in view of the claim which had been put forward that "it will free the British textile industry and scores of other important industries from the bonds of Germany," whilst "when the war is over Great Britain will be in a position to compete equally with Germany in the matter of dyed goods in every market of the world."

I am willing to believe that the story was published in perfect good faith as a piece of honest journalistic enterprise, with a happy feeling that something really important had been accomplished and with a desire to hearten the public by good news; but it is really shocking, after the public attention which the subject has received, to encounter a picture of the dye-problem so illusory as the one mentioned. It suggests a revival of the poisonous heresy, very popular when war began, that Germany had stolen the dye-industry from this country, and that therefore we could steal it back. It evidently needs to be said again that Germany did not steal the dye industry from this country. Germany earned the dye industry, won it from Nature by hard work, indomitable patience, far-sighted employment of profits in fresh experiments, skilful organisation of resources, careful attention to the requirements of customers, scientific

control of manufacturing operations, ever-widening enlistment and encouragement of chemists, utilisation of by-products, ingenious application of engineering principles, and acquisition of cheap raw materials. If, after nearly four years of war, we cannot clear our minds of the pitiable nonsense which would suggest that forty years' exercise of these factors may be packed in a Foreign Office bag and stolen, we shall not only fail to establish the dye industry, but we shall richly deserve to fail. Incidentally, may I respectfully suggest to Lord Northcliffe that he should employ a trained chemist to review all impending articles on chemical subjects prior to publication in his otherwise enterprising journals?

This particular incident, whether grave or gay, according to the mood of the observer, illustrates very clearly one of the principal obstacles to an accurate valuation of their debt to organic chemistry by the public. Unlike astronomy, botany, geology and zoology, organic chemistry is extremely difficult to popularise—that is, to render interesting and intelligible to those without preliminary training in the subject. Consequently it happens that although every human being is a practical organic chemist, whose laboratory is occupied with complex experiments during every hour of the twenty-four, beginning with the matutinal porridge and bacon, the interest which is taken by the vast majority in these operations begins and ends with the satisfaction of hunger and the quenching of thirst. Even those who have the misfortune to suffer from indigestion do not reproach themselves for lack of skill in the practice of organic chemistry.

If we turn to the manufacturing side of the subject, a similar handicap in comparison with other crafts is presented. The visitor to a steel foundry is rightly thrilled at the sight of a ton of "pigs" dropping into the converter with as little disturbance as a lump of sugar falling into his after-dinner coffee, and he is very properly dazzled when many tons of limpid steel flow from the ladle as gently into the mould as a bottle of port into the decanter. The various processes of cotton-spinning and weaving delight the observer by their complexity and precision, whilst the growth of an automobile during an afternoon's curiosity engenders a warm feeling of respect and admiration for Mr. Ford and his fellow-craftsmen. All these experiences may be freely enjoyed without any preliminary knowledge of the properties of iron, the characteristics of cotton, or the laws of motion. Everything is different, however, in a chemical factory, inspection of which can be thoroughly appreciated only by those accustomed to practising similar operations in laboratory surroundings, when the principal enjoyment arises from the task of tracing the extraordinary liberties with laboratory practice which factory operation is compelled to take. The casual observer, even if he overcomes a natural distaste for fumes, live steam, and unfamiliar but suspicious odours, cannot unravel the maze of pipes and tubs and closed iron vessels which imprison the material undergoing change; the conversion of naphthalene into beta-naphthol, of aniline into para-nitraniline, or of nitrobenzene into benzidine, leaves him cold, because the finished product in each case is just as unfamiliar as the starting material, and is equally purposeless.

This blank in the training of the public, especially among those who are supposed to be the best trained, has played, and is still playing, an important part in retarding the development of a national dye industry. Not merely the incident of the "257 recipes," but others less ephemeral, indicate that even yet the crux of synthetic colour manufacture is not fully recognised in this country. Even yet it is not understood that the production of a colouring matter is but the culminating step in a long series of complex organic chemical operations directed towards converting the simple products of coal-tar distillation into the more complicated organic compounds known as "intermediates," so called because they are the stepping-stones between raw materials derived from coal-tar and synthetic dyes required by the dyer. If dye-making is ever to become established on a firm basis in this country, unceasing efforts must be devoted to manufacturing these intermediate products at the highest efficiency as to quality and cost, and to securing the necessary raw materials at the lowest possible rates. The achievement of this aim, which has been accomplished by German dye-makers during a period of forty years, and with indispensable assistance from a rapidly increasing body of trained chemists, will demand an outlay of capital much larger than has been ventured hitherto; moreover, the capital at first will appear to be unproductive, because it is only when the intermediate products for which it is laid out are actually manufactured that the ultimate object of dye-making can be accomplished. So long as we purchase "intermediates" in

Switzerland, the United States or elsewhere, we cannot claim to have established an independent British dye-making industry. Much of the uninformed criticism which has been levelled against British colour-makers by their fellow-countrymen arises from failure to understand and appreciate this cold fact. Bread cannot be made without flour, and it is just as reasonable to expect the weaver to produce fabrics without yarn as to demand colour from the colour-maker when capital for manufacturing the necessary intermediate products is withheld from him.

Nearly three years ago I ventured to prophesy that American progress in the field would be more rapid than our own, and a review of the development of this industry across the Atlantic has justified the forecast. The basis of their advance is to be found in the great scale on which essential intermediate products are being manufactured, and in the moral support which has been given by their Government in the shape of a tariff. It has not been found necessary for the United States Government to accord financial assistance to the dye-makers, because the promised defence against "dumping" and "all-line forcing" has appeared adequate to justify the venture of private capital, which has been amply forthcoming. It would appear to follow that in this country, if the State is not willing to give the fiscal guarantee, it must find the money.

[Since these words were written a declaration of Government policy has been made in the House of Commons by the President of the Board of Trade (May 15th, 1918). The following words are quoted from the Hansard report of his address:—

"In the first place, we are proposing, where a manufacturer of dyes will undertake the manufacture of special dyes, and where he is not in a position to secure the necessary money to provide for extensions to building and plant, to make a loan at a fixed rate of interest, in no case being less than 5 per cent. It is also proposed to do as is done by the Ministry of Munitions in many thousands of cases. Where extensions of plant and buildings are necessary immediately, and where there is difficulty owing to the excessive costs of making these extensions, the Government will make some provision to meet the cost of these extensions, so that they may be immediately dealt with, and thus afford the additional facility that is required for the manufacture of these special dyes. It is also proposed to make certain grants in respect of research work. Those who have a knowledge of this industry realise the enormous amount of research work associated with the manufacture itself. There is a further proposal, and that is that, in order to safeguard this particular industry against the great efforts which these great German dye-making firms are certain to make after the war to destroy all we have accomplished through the war, and to make this industry again subservient to Germany, we will adopt a course, which I believe I am right in saying was carefully considered by a Cabinet Committee of the last Government, and recommended to and approved by the Government of that day, and which has since been approved by the present Government. It is that importation of all foreign dyestuffs shall be controlled by a system of licences for a period of not less that ten years after the war. . . . We have been in consultation with representatives of dye-makers and dye-users, and they, I am glad to say, are in agreement on this matter. I have agreed with them that a licensing authority shall be established by the Board of Trade, which will have a free hand in deciding as to the grant of licences. That Committee is to be composed of an equal number of representatives of dye-makers and of dye-users, in each instance nominated by these interests. There will be an independent Chairman of this Board, a man of good business standing, appointed by the President of the Board of Trade."

For all those who have laboured in bringing to the attention of their fellow-countrymen the vital importance of chemical study, there are hope and inspiration to be derived from this pronouncement.]

Money, however plentiful, and State encouragement, however wise and cordial, will not alone suffice for the purpose in hand.

"The Moving Finger writes; and having writ,
Moves on: nor all your piety nor wit
Shall lure it back to cancel half a line,
Nor all your tears wash out a word of it."

For those who have eyes to see and intelligence to understand, the Moving Finger has written more clearly on the walls of this industry than elsewhere. The boundary-line between German success and British failure in the fine chemical industry stands defined as clean and sharp as if cut out of metal. Briefly stated, it lies in the allocation of profits. A farmer who reaps a field of corn and garners the product can either sell it and pocket the proceeds, or he can sell enough to pay the rent of the field, the labour which has been expended upon it, and a modest return on his capital, utilising the remainder to produce next year's crop. Adopting the latter course he has a still larger crop, whilst the former course gives him none. The German chemical farmers have chosen the far-sighted practice, each year devoting more and more seed, in the shape of constantly widening

chemical studies, to sowing new fields. On the other hand, many of our chemical farmers engaged in coal-tar colour manufacture have taken the short view, withdrawing such handsome personal profits as, had they been returned to the industry and sown in the conduct of scientific experiments, would have produced the abundant harvest which has been reaped by Germany.

On September 9th, 1912, Carl Duisberg, managing director of the Farbenfabrik vormals Friedrich Bayer, stood surrounded by the splendid fruits of this policy, addressing the Eighth International Congress of Applied Chemistry, and I can recall, quite vividly, my own sensations on that occasion. They were the delight and admiration of a chemist in the achievements of chemists, shadowed by the shame and regret of an Englishman in contemplating the slender part played by his own country in the dazzling developments of chemical investigation. A multitude of German chemical products covered the table and overflowed to the platform, whilst the address itself was a florid eulogium of German chemical enterprise. The following words, however, call for special attention, indicating as they do the mainspring of this vast mechanism: "In the chemical works of Germany pure chemical science receives its due. In every branch of inorganic, organic and physiological-biological chemistry we are working with an army of scientifically trained men."

Six years earlier, on the occasion of the Perkin Jubilee, the same captain of German chemical industry was analysing the causes of German predominance in coal-tar colour and drug manufacture, and said: "Although the Englishman is in general practical, he is wanting in that particular quality for which we Germans are remarkable—*i.e.* not perseverance, but patience and the power of waiting for success. For all that the Englishmen does he expects soon to be compensated in hard cash. In no field of technical work must one toil with such patience, and even with the eventual relinquishment of material recuperation, as in the coal-tar colour industry. It does not suffice merely to plough and dig up the soil in the most ardent manner, it does not suffice to impart to it mental and intellectual manure of all kinds—*i.e.* nitrogen in the shape of skilled technical chemists, and phosphorus in the form of distinguished inventors and scientific chemists, for both of these are purchasable and have often been tried; but it requires above all a singular ability to wait and bide things coming, combined with endless patience and trouble until the ground is finally mature and capable of developing new kinds and species. We Germans possess in a special degree this quality of working and waiting at the same time, and of taking pleasure in scientific results without technical success."

These words were uttered in a moment of expansion by the man who, perhaps better than any other, is qualified to give an opinion, and than whom no one could express it more clearly and forcefully. Entering the Elberfeld Farbenfabrik in 1884 as an assistant chemist at a salary of £90 per annum, it is to his unbounded energy and unquenchable optimism, guided and controlled by deep scientific insight and shrewd commercial faculty, that the establishment and success of the Leverkusen factory are principally due. In presenting this picture of ourselves as others see us, it may be of interest simultaneously to present a portrait of the artist by the President of the Hansa League in 1909, when he addressed Carl Duisberg, then completing twenty-five years' service with the company, in the following terms:—

"That your industrial success and activity have been constructed on scientific foundations, extended by scientific discoveries, and by scientific methods elevated to a high altitude, is shown by your title of Professor conferred by the State and by the honorary degrees of Doctor which you hold in two faculties. This alone, however, is insufficient to explain the powerful, even dominant influence which you exert upon those with whom you come in contact, be they colleagues or subordinates. It is more a property which you possess in addition to warm-heartedness, in addition to that wide range of vision enabling you to recognise the demands of the future equally with those of to-day, a property which marks you out and brings you closer to our German hearts. For you possess that true German idealism which happily has not yet deserted our nation of poets and thinkers, although we be compelled by the stern struggle for existence to place economic interests in the foreground. Withstanding the corrosion of industrial rivalries, you have proved in all your being and your work that those elements which can be neither seen, nor weighed, nor grasped are nevertheless the greatest, the best, the most indispensable in our lives, namely, ideals. Your ideal has been the honour, progress and triumph of your undertaking, the fortune and advancement of those who stand under your command, and not least, the increase of power, of reputation and of dignity to our Fatherland."

This particular selection is made from the 120-page book of similar utterances on that occasion because it appears to reveal, in clear

and striking language, the *Leitmotiv* and driving principle of the German industrial aristocracy. The combined appeal to legitimate pride, to chastened self-interest, and to the highest patriotism conveys a lesson which no Briton can afford to ignore.

Moreover, the creed goes far to explain, although it does not condone, the exasperation and resentment of Germany at the relative pre-war position of the two countries, largely instigating the crime which that country has committed against civilisation. I can imagine that the German argument would be somewhat as follows:—We find ourselves an association of nearly seventy million people, not yet fifty years old as a nation. With few gifts of Nature and fewer geographical advantages we have, by our industry and co-operative determination, adapted the teachings of modern science to every branch of commerce. In doing so we have not neglected the physical and mental well-being of the operatives concerned in these developments, and whose livelihood depends on their success. Nor have we ignored the fount by which this marvellous growth has been irrigated, namely, abstract knowledge and investigation, for our numerous universities open their gates to the youth of every class, and our teachers are honoured in the land. Engaged in these arts of peace, and profiting enormously by their material results, we have nevertheless continued to make such sacrifices of time, convenience and money as are necessary to military preparation, and have simultaneously gained a position excelled only by your own on that element which is historically and geographically yours, and correspondingly alien to our history and geography—the ocean. Meanwhile, what is your record? You are an ancient race, which has now stood for centuries in the forefront of the battle for liberty and progress. Your pioneering predecessors, assisted by the blunders of your adversaries, have lavished upon you priceless territorial jewels. All these you have accepted with a sublime disregard for the duty which you owe to Destiny, for whilst *noblesse oblige* may be your motto as individuals, it seldom appears to inspire your politics. You were the first to reap the harvest of the industrial revolution, yet for half a century your factory system was a disgrace to civilisation. Your inventors and discoverers have lingered in oblivion unless they happened upon some device by which their researches could be turned immediately into gold. Abstract knowledge meets with your polite but callous indifference. Your rulers have been drawn systematically from those in whom this indifference is the most profound, and whilst displaying high qualities of honourable statesmanship, they have studiously ignored the vital and revolutionary forces which had reached a crescendo of world-activity in the closing years of the nineteenth century. Your people, wholesome and cleanly in their family relationships, have nevertheless shrunk from the one sacrifice which, in ultimate issues, offers the only safeguard for their homes; they have preferred to devote their leisure to sport and amusement, which they more often pay to witness than practise in person. Instead of being directed towards those great problems of social amelioration, racial harmony and the co-ordination of resources which your splendid empire has imposed upon you, your political energies appear to be largely dissipated in pitiful squabbles between the "ins" and the "outs." With your record of neglect, you then have the effrontery to scowl at our record of achievement, and to grudge us a place in the sun. *Gott strafe England!*

Naturally I do not subscribe to this indictment, but I believe it to be the German standpoint, and in that sense it merits attention.

The conclusion of the matter appears to be roughly this. It takes all sorts to make a world, and the world, as we find it, contains Germans. Even when justice has finally triumphed, however many Germans may be destroyed in the process, there will still survive more millions than the inhabitants of this country. For us it is necessary to face the facts which, upon our easy-going people, have dawned somewhat slowly. At the beginning we were willing to believe that it was the Kaiser's war as distinct from the German people's war. The world has now learned our mistake. Lichnowsky, among others, has proved that in one sense it was the Kaiser's war, but in doing so has proved that it is the war of the German people also, because, with convincing evidence before them, they have not disowned the war, and other circumstances, too many and too disgusting to enumerate here, have established the proof.

How does this affect chemistry? It affects chemistry and modern science generally, because the scientific men of this country require to watch closely their claim to scientific honesty. We must guard ourselves against the danger of allowing admiration for German scientific achievements to blind our eyes to German

popular brutalities. Let us closely study the achievements and use all our powers to surpass them, but let us never, so long as we claim to be human beings, forget or forgive the brutalities. Let us remember that if we aim at being scientific men, as distinct from scientific machines, we must be men first and scientific afterwards; men with human hearts, which can be torn by the ruthless destruction of children, by the murder and worse than murder of women, by the neglect and starvation of helpless prisoners, and by the public spitting in their faces. Wretches who perpetrate such abominations, or who condone them, are not fit for association hereafter with decent men, and human facts of life being more important than chemical facts, it is grossly unscientific to ignore them. The abominations must be brought into account, just as much as the synthesis of indigo, salvarsan, indanthrene and nitric acid from the atmosphere, and no man who lays a claim, however strong, to be regarded as a scientific man can pretend for one moment that they do not vastly preponderate.

DISCUSSION.

The Chairman (Sir William A. Tilden, D.Sc., LL.D., F.R.S.), in opening the discussion, said no one could have listened to the paper without feeling almost personally the reproaches which the author had justifiably launched against this country for its indifference and torpidity in the past. He did not think any English man or woman could refuse to accept the statements made towards the end of the paper, and he sincerely hoped that all of them, especially the young men who might find their way into industries in the future, would take to heart the lessons so clearly set forth in the body of the paper.

Dr. J. C. Cain wished to call attention to the difference in the organisation of scientific manufactories in England and Germany, that difference consisting chiefly in the composition of the boards of directors. Before the war such works in England were not as a rule directed by scientifically trained men, but by what were generally known as business men, the directors meeting perhaps once a month to ascertain how the work was going on and to learn what dividends were going to be paid. The boards of directors in Germany, however, actually directed. They were composed of men who had prominent positions in the works, such as the chief chemists and the chief engineers. The business men and capitalists were also represented, and every man on the board knew something about the business which he helped to direct. In connection with the author's concluding remarks, with which he entirely agreed, it was almost impossible to attend a meeting of chemists in London without being irritated and annoyed by the presence of Germans, and he thought those Germans should be requested not to attend chemical meetings during the war. The paper read at the present meeting would probably be fully reported in German scientific journals.

The Secretary (Mr. G. K. Menzies) said that when the present meeting was first arranged he was very anxious that the author should not have to preach only to the converted, and he made such efforts as he could to secure the attendance of a number of manufacturers. He was sorry to say that he had not been very successful, partly because manufacturers were very busy at the present time and partly because they seemed to be somewhat shy of attending such meetings, where they were afraid remarks not altogether complimentary would be made about them. Amongst others he wrote to Sir George Watson, the Chairman of the Maypole Dairy Company, who replied that he would have been very glad to come had he not been out of town. In January last Sir George Watson read an admirable paper before the Society, in the course of which he made several remarks which were very relevant to the present paper. He said: "At Maypole's refining mills and margarine works we consider the laboratories to be one of the most important parts of the organisation, and no expense for research is spared there which will help towards future progress. I fear that in the past some British manufacturers have not attached so much importance to the expert and scientific assistance of their chemists and chemical engineers as their Continental competitors." In replying to the discussion, Sir George Watson also said: "With reference to manufacturers employing chemists, those chemists should be given seats on the board of directors, as is the case in the Maypole Company, so that they can become fully acquainted with all the details of the business." On his own behalf he would like to say how very much he had appreciated Dr. Forster's paper. He was, unfortunately, not qualified to criticise it on the technical side, but as a literary performance he thought it admirable.

The Chairman, in proposing a vote of thanks to the author, said he had listened to the paper with the very greatest interest and satisfaction. The British public were still in a state of torpor, more particularly with regard to such industries as those mentioned in the paper, and he hoped the author would take every possible opportunity to stir them up to action. One could not complain because the ordinary British citizen did not know anything about organic chemistry, and probably did not even understand what the expression meant, but what he was continually complaining about was the fundamental and profound ignorance of every kind of science which was manifested by the British public. Not very long ago there were dozens of colonels and countesses and reverend

gentlemen who were prepared to testify publicly that by adding a teaspoonful of a certain powder to a ton of coals the heating power of the coal could be increased 50 per cent. That of itself was sufficient to show the ignorance of the British people with regard to science. Those people were educated people, who would be offended if anyone said they were grossly ignorant, and yet they did not know one of the fundamental principles of physical science. One had only to look at the advertisements in the daily papers to see how gullible the British public was. The words "radium" and "argon" were applied in all kinds of different ways, and the people who responded to the advertisements had not the least idea what radium and argon were. The cure for that widespread ignorance was, as the author had stated, a reform of our educational system. The public schools had been saying for the last forty years that they taught science to all their boys and girls, but that was not true. Many of those institutions had excellent laboratories and competent masters and mistresses, but when they said they taught science, it only meant that a portion of the school devoted two hours a week to the subject, while they devoted twenty-five hours to other subjects. They did not give science a reasonable and fair proportion of time and attention. "Science" implied some knowledge of the whole of the physical universe in which we found ourselves. How many people knew anything about why the sun rose in the east and set in the west, or why the days were longer in summer than they were in winter? How many people could tell what was the nature of the soil they walked upon daily? On the previous day he was talking to a soldier, and mentioned that he lived on the edge of the London clay, and the soldier did not know what that meant—he did not know what clay was. Again, how many people knew the chief divisions of the animal kingdom, or could recognise the botanical relationships of the commonest plants? Yet those people would be offended if they were called uneducated. He complained particularly that not only was that ignorance prevalent generally throughout the community, but that it extended and became, in some respects, intensified as one went from the bottom of society to the top. How many men in the House of Commons could claim to have had an education in which science occupied a fair position? He had been trying to think whether there was anyone in the Government offices in Whitehall who was qualified to deal with scientific questions, and he could only think of one—an eminent mathematician—who was by predilection occupied chiefly in the study of ancient Greek geometry. That was not a state of affairs with which we ought to be satisfied. He was firmly convinced that the present Government was doing its best in the conduct of the war, and he did not believe in perpetually worrying the Government about other matters, but if the nation was to continue in a position of safety and reasonable prosperity, such things would have to be considered when the war was over.

The resolution was carried unanimously.

DR. M. O. FORSTER, in reply, said that his only serious connection with industry dated from the beginning of the war, so that the Chairman's criticisms clearly could not apply to him. He would like the meeting to return a hearty vote of thanks to Sir William Tilden for occupying the chair. He had been associated with Sir William for the last twenty-five years, and it had been a very great pleasure to him personally that Sir William should have presided on the present occasion.

The meeting then terminated.

THE ECONOMIC SITUATION IN INDIA.

A section of the monumental report of Mr. Montagu and Lord Chelmsford on Indian Constitutional Reforms is devoted to "Industries and Tariffs." In the course of their investigations the criticism was forced on the Secretary of State and the Viceroy that economic factors enter largely into the political situation, and they say they feel bound so far to exceed the limit of strictly constitutional discussions as to take note of these also.

The poverty of the people raises the question whether the general level of well-being could not be materially elevated by the development of industries; the lack of outlet for educated youth has contributed not a little to political unrest in Bengal, and discontent has been aroused by India being so largely dependent on foreign countries for manufactured goods. The fact that India's foreign trade was largely with the United Kingdom gave rise to a suspicion that her industrial backwardness was positively encouraged in the interests of British manufactures, and the maintenance of the Cotton Excise Duty is widely accepted as proof of such a purpose.

Under the Company commercial development was, of course, a matter of business. *Laissez faire* doctrines and fear of State competition with private enterprise affected the later attitude of the Government. As the desirability of industrial expansion became clearer, the *Raj* fully shared the desire of Indian leaders to secure the economic advantages that would follow the local manufacture of raw products. English theories as to the limits of the State's activities are inapplicable to India, and if the resources of the country are to be developed the Government must take action. The attempt to boycott British goods, encouraged or countenanced by the advanced politicians as a means of putting pressure on manufacturing opinion in Britain in favour of the annulment of the partition of Bengal, was ineffective, and certain indigenous enterprises which sprang from the *swadeshi*

movement failed through inability to apply some degree of technical knowledge under commercial conditions. The people have now recognised that they cannot carry out their own programme without the help and guidance of Government, and they confine themselves for the most part to pressing their claims for State assistance and tariff discrimination against foreign imports. On the outbreak of war they welcomed the prohibition of imports from enemy countries as affording India an opportunity of replacing foreign articles by her own products.

"After the war the need for industrial development will be all the greater unless India is to become a mere dumping-ground for the manufactures of foreign nations, which will then be competing all the more keenly for the markets on which their political strength so perceptibly depends. India will certainly consider herself entitled to claim all the help that her Government can give her to enable her to take her place as a manufacturing country; and, unless the claim is admitted, it will surely turn into an insistent request for a tariff which will penalise imported articles without respect of origin. On all grounds a forward policy in industrial development is urgently called for, not merely to give India economic stability, but in order to satisfy the aspirations of her people, who desire to see her stand before the world as a well-poised, up-to-date country; in order to provide an outlet for the energies of her young men who are otherwise drawn exclusively to Government service or a few overstocked professions; in order that money now lying unproductive may be applied to the benefit of the whole community; and in order that the too speculative and literary tendencies of Indian thought may be bent to more practical ends, and the people may be better qualified to shoulder the new responsibilities which the new constitution will lay upon them."

On military as well as economic grounds Imperial interests demand that the natural resources of India should be better utilised. The possibility of sea communications being temporarily interrupted forces us to rely on India as an ordnance base for protective operations in Eastern theatres of war.

"We are agreed, therefore, that there must be a definite change of view; and that the Government must admit and shoulder its responsibility for furthering the industrial development of the country. The difficulties by this time are well known. In the past, and partly as a result of recent *swadeshi* experiences, India's capital has not generally been readily available; among some communities, at least, there is apparent distaste for practical training, and a comparative weakness of mutual trust; skilled labour is lacking, and although labour is plentiful, education is needed to inculcate a higher standard of living and so to secure a continuous supply; there is a dearth of technical institutions; there is also a want of practical information about the commercial potentialities of India's war products. Though these are serious difficulties, they are not insuperable; but they will be overcome only if the State comes forward boldly as guide and helper. On the other hand there are good grounds for hope. India has great natural resources, mineral and vegetable. She has furnished supplies of manganese, tungsten, mica, jute, copra, lac, etc., for use in the war. She has abundant coal, even if its geographical distribution is uneven; she has also in her large rivers ample means of creating water-power. There is good reason for believing that she will greatly increase her output of oil. Her forest wealth is immense, and much of it only awaits the introduction of modern means of transport, a bolder investment of capital, and the employment of extra staff; while the patient and laborious work of conservation that has been steadily proceeding, joined with modern scientific methods of improving supplies and increasing output, will yield a rich harvest in future. We have been assured that Indian capital will be forthcoming once it is realised that it can be invested with security and profit in India; a purpose that will be furthered by the provision of increased facilities for banking and credit. Labour, though abundant, is handicapped by still pursuing uneconomical methods, and its output would be greatly increased by the extended use of machinery. We have no doubt that there is an immense scope for the application of scientific methods. Conditions are ripe for the development of new and for the revival of old industries on European lines; and the real enthusiasm for industries, which is not confined to the ambitions of a few individuals, but rests on the general desire to see Indian capital and labour applied jointly to the good of the country, seems to us of the happiest augury."

Many Indians urge that the Government should make up by financial subsidies the ground which has been lost by what they regard as State indifference. The extent and form of State assistance will be questions to be determined by the reformed Governments of the future, with the advice of the Industrial Commission before them, and with due reference to Imperial interests. But if the speculative element in Government activities is to be minimised, there must be a marked expansion of the technical services of the country. The Industrial Commission has not yet submitted its report; but it is understood that it is likely to lay stress on a substantial increase in the scientific and technical services of the country and their organisation under a separate department of the Government of India.

With regard to fiscal policy, the Secretary of State and the Viceroy have "no immediate proposals to make," but for the information of His Majesty's Government they put forward a succinct and impartial statement of the views of educated Indians upon the subject. The authors of the report believe that the theoretical free trader "hardly exists in India at present."

In a separate paragraph on the "The Non-Official Community" they observe, *inter alia*—

"When complaints are rife that European commercial interests are selfish and drain the country of wealth which it ought to retain, it is well to remind ourselves how much of India's material prosperity is due to European commerce."

NOTES ON BOOKS.

TIDAL LANDS: A STUDY OF SHORE PROBLEMS. By Alfred E. Carey, M.Inst.C.E., and F. W. Oliver, F.R.S. London: Blackie & Son, Ltd. 12*s*. 6*d*. net.

This book deals with a number of the problems connected with the maintenance and control of coastal and riparian lands, and especially the changes which may be effected by vegetation. The subject is one of great importance and interest to engineers, to landowners, and to all concerned with the question of coast erosion.

The phenomena connected with tides, wind effects, currents, and river velocities, are discussed in the first two chapters, and then, after a section on the foreshore, we come to the portion which treats of vegetation. This is very full and of particular value. The manner in which sand dunes may be fixed by the growth of various kinds of marram grasses is described in detail; diagrams are given to show the effects of planting, and some excellent photographs illustrate the results obtained. A good deal of attention is naturally devoted to Holland, the very existence of which depends to a large extent on the maintenance of its sand dunes.

Shingle beaches are next discussed, and the ways in which they may be protected and utilised by planting. The reclamation of tidal lands is also treated. A special chapter is devoted to "Blakeney Point, Norfolk, from an Engineering Point of View," which is selected as a suitable demonstration area on the coast; and the work concludes with two chapters on State and local control and complementary problems.

The book is written throughout in a scholarly style; it contains a great deal that is original; and the scientific portions show evidence of careful research and observation.

GENERAL NOTES.

BRITISH GUIANA AND THE PROBLEM OF ITS DEVELOPMENT.—In the House of Commons on July 4th Colonel C. E. Yate asked the Secretary of State for the Colonies whether his attention had been called to the lecture lately delivered at the Royal Society of Arts by Sir Walter Egerton on the subject of British Guiana; and what steps would be taken to carry into effect the nine different reforms advocated by that officer? The Under-Secretary of State for the Colonies (Mr. Hewins) replied as follows: "The answer to the first part of the question is in the affirmative. Generally speaking, the measures advocated by Sir Walter Egerton have received, and are receiving, a great deal of attention. Some of them are being carried out; but others are of such a nature that they cannot be dealt with during the war, and one involves political changes on which I am not prepared to express an opinion. As regards the scheme for a railway to the interior, upon which Sir Walter Egerton lays such special stress, a practical step is already being taken by clearing a cattle track along a line which coincides with one of the proposed tracks.

WATER-POWER RESOURCES COMMITTEES.—A representative committee, appointed by the Board of Trade, is examining the water-power resources of the United Kingdom, and the extent to which they can be made available for industrial purposes. The chairman is Sir John F. C. Snell, M.Inst.C.E., and the secretary Mr. R. T. G. French, 10, Princes Street, Westminster, London, S.W. 1. Mr. E. S. Montagu recently stated in the House of Commons that the Government of India propose to constitute a small committee of electrical, mechanical, and irrigation experts to visit the different provinces, and, after conference with the local officers, to examine promising sites and to report whether a detailed survey is worth undertaking.

PRODUCTION OF SUGAR FROM THE PALM.—In a note which appeared recently in the *Journal*,* reference was made to a new industry, viz. the manufacture at Loano of cattle food from various waste substances, the sugar used being obtained from a species of wild date palm, which grows abundantly on the Ligurian coast, as well as on the French Riviera. The manufacture of sugar from the palm tree is no novelty to our Indian readers, although unknown hitherto on the shores of the Mediterranean. In Southern India, large quantities of sugar are obtained from the wild date palm by the natives. The trees are tapped by making an incision in the bark, just below the flowering stem. The sap which flows from this cut is collected in small earthenware pots or jars, holding about half a pint each. These pots are collected morning and evening. The liquid so obtained is boiled down, leaving a kind of coarse dark-brown sugar. The pots must be kept scrupulously clean and whitewashed, in order to prevent fermentation. This sugar is used chiefly by the natives, and is regularly sold in the bazaars. It is known by the native name of "Chakara," pronounced "Jaggery" by Europeans.

* See *Journal*, November 30th, 1917, page 35, Vol. LXVI., "Substitute for Bran."

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REGISTERED AS A NEWSPAPER.

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The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

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Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

All communications respecting Advertisements should be addressed to the ADVERTISEMENT MANAGER, 97, GRESHAM STREET, E.C. 2.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO SIR RICHARD GLAZEBROOK.

The Council of the Royal Society of Arts attended at Clarence House on Thursday, the 18th inst., when His Royal Highness the Duke of Connaught and Strathearn, K.G., President of the Society, presented its Albert Medal to Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S., "for his services in the application of science to the industries of peace and war, by his work as Director of the National Physical Laboratory since 1899, and as Chairman of the Advisory Committee for Aeronautics."

The members of the Council present were: Mr. Alan A. Campbell Swinton, F.R.S. (Chairman), Sir Charles Carrick Allom, Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., Lord Blyth, Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S., Dr. William Henry Maw, Major-General Sir Desmond D. T. O'Callaghan, R.A., K.C.V.O., Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S., Sir Francis Taylor Piggott, LL.M., Sir Boverton Redwood, Bt., D.Sc., F.R.S.E., Lord Sanderson, G.C.B., K.C.M.G., Mr. John Slater, F.R.I.B.A., Mr. James Swinburne, F.R.S., Mr. Carmichael Thomas, Sir Henry Trueman Wood, with Mr. G. K. Menzies, Secretary.

EXAMINATIONS.

The results of the Stage III. (Advanced) examinations, held from May 6th–16th last, have now been sent to the centres concerned. It is hoped to issue the results of the Stage II. (Intermediate) examinations at the end of this month, and those of the Elementary Stage about the middle of August.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

A meeting of the Indian Section was held on Thursday, June 20th, 1918; The Right Hon. E. S. Montagu, M.P., Secretary of State for India, in the chair.

The Chairman, in opening the meeting, said he much appreciated the invitation which the Royal Society of Arts had extended to him to take the chair on that occasion. He was well aware of the valuable Imperial work which the Society performed in bringing important questions, such as those connected with India, before the public. He regarded it as a matter of great importance that the public should be well informed on Indian questions and the development of India, which had been so rapid in recent years. It was only by constant discussions on Indian questions that it was possible to give those who unfortunately had no personal connection with the country an idea of the rapid progress there was in every direction. That progress had been much fostered by the war, which had given India increasing opportunities of showing her loyalty to the Crown and of co-operating with other parts of the Empire in the great task in which they were engaged. It was because he appreciated the work that the Society did to enlighten the public on those and kindred topics that he was particularly pleased to be able to accept their invitation to preside at the present meeting, when Sir Dinshaw Wacha's paper was to be read. Unfortunately Sir Dinshaw was in India, and therefore could not attend to read his paper in person. To those who had lived in Bombay Sir Dinshaw needed no introduction; his name had for long been a household word in that city, and there was no one to whom it was not very thoroughly known. Educated in Bombay, and finishing his education at the Elphinstone College, he at once associated himself with other graduates who issued from that institution in the early sixties. Prominent among them was the late Sir Phirozshah Mehta, between whom and Sir Dinshaw Wacha there had been both a lifelong friendship and a lifelong collaboration in municipal and political endeavour. Together they wielded great influence in the Municipal Corporation of the City of Bombay, which,

under their guiding influence, had earned a record second to that of no other city in India. Equally together they fostered for many years the growing political aspirations of their fellow citizens, and, working always on constitutional lines, they did much to advance political ideas, primarily among the people of Bombay, but also throughout India generally.

The paper read was—

INDIAN COTTON AND THE COTTON-MILL INDUSTRY.

By The Hon. Sir Dinshaw E. Wacha,
Chairman of the Bombay Millowners' Association.

It is scarcely necessary to observe at the outset that cotton and cotton manufactures occupy a foremost place in point of value among the few principal articles of merchandise which India annually exports to foreign countries. Her total exports of all kinds of commodities during the quinquennium which ended on March 31st, 1914, averaged £146·30 million per annum. Of these the six articles specified below alone amounted to £123·30 million:—

	Million £
1. Grain, chiefly rice and wheat	30·50
2. Cotton and cotton manufactures	29·79
3. Jute and jute manufactures	28·30
4. Seeds	16·24
5. Hides and skins	9·72
6. Tea	8·71

As far as raw cotton exports are concerned, it may be said that their value averaged £22·18 million during the quinquennial period just referred to, while the amount recorded on March 31st, 1917, was £22·78 million, though the quantity of the raw material itself had necessarily undergone diminution and was comparatively less than that exported on March 31st, 1914. India, it is superfluous to say, is not the only country which extensively grows cotton. Firstly, there are the United States of America, and, secondly, Egypt. These three countries supply by far the largest quantity of cotton grown in various parts of the world. Thus Indian cotton is, for all commercial purposes, in no way a "monopoly" article of merchandise as jute is; the world which consumes jute almost wholly depends on India.

Antiquity of Indian Cotton.

From the earliest historical times cotton and cotton fabrics have been well known. The ancients were well aware of these, as related by Greek and Roman geographers and travellers. The Old Testament also bears testimony to the fact. But it is needless to refer to foreign historians when there is ample evidence in the indigenous literature of the country of the cultivation of the cotton-plant—"the white wool growing on the tree" of Herodotus—and also of the fabrics made therefrom. Cotton thread and cotton cloth have been known in India from the remotest antiquity. It is related of the Hindu gods and goddesses of the Vedic period how they wore woven garments. The Aryans who invaded the country later found the industry of cotton-spinning and weaving well established. In the Indian epics of the *Mahabharata* and the *Ramayana* mention is made of cotton goods of divers designs. There is no doubt that the fine muslins of Eastern Bengal, such as "The Evening Dew" or "Running Water," were made anterior to the invasion of the Aryans. In his excellent book on the "Cotton Plant," Mr. R. B. Handy, of the United States Agricultural Department, mentions that cotton thread and cloth were referred to in the laws of the great Hindu lawgiver, Manu (800 B.C.). Professor Sayce, in his Hibbert Lectures, expresses his belief that cottons were exported to the head of the Persian Gulf in the fourth millennium B.C. Again, it is related by the great Greek historian that the Indian contingent who accompanied the army of Xerxes in his invasion of Greece (480 B.C.) were seen in white cloth, which could not be aught else than cotton. According to the *Imperial Gazetteer*, Asoka is said to have sent missionaries to Pratisthana of the Sanskrit books, in the Godavery district, and inscriptions of the second century before Christ in the Petalkhara caves refer to the kings and merchants of Pratisthana. Further evidence is to be found of the growth of cotton in the first century of the Christian era in Surashthra, the ancient Syrestrene, which is described as a fertile country, yielding wheat and rice, sesamum oil and ghee, cotton, cotton cloths and silks of a variety of designs. Pratisthana was an *entrepôt* of the cotton industry. The Sanskrit word for cotton is Karpāsa, which is the same generic word as Kapās, commonly used all over India. The Hebrews had a similar word, "Carpas," the Greeks "Karpasos," and the Romans "Carbasus."

It was the Arabs who called it "Kutan," whence the English word cotton. Both Pliny and Pollux state that cotton was grown in the island of Tylos, in the Persian Gulf, and, according to Theophrastus, in Arabia also. Again, the author of the "Periplus of the Erythrean Sea" confirms this by mentioning it as an article of export from Ommana (Oman).

Even to-day there is a port in the Red Sea, near Hodeida, called Comfidda, whence cotton is exported.

Old Indian Trade Routes and Traders.

A few words may be said here as to the routes by which Indian trade was carried on. Modern Cambay and Broach (the Bhrigukacha of Sanskrit and Barygaza of the Romans) were the two centres where, of old, Indian merchandise for export to Arabia, Egypt, and distant Rome, gravitated from the north, the east and the south. Thence the goods were transported in native craft, almost identical with the buglas, prows, etc., of our days, to the Persian Gulf and Aden, as far as Mocha (Mūsā). There the products of Egypt and Arabia, and also treasure from Rome, were exchanged by Roman, Greek, Egyptian and Arabian merchants. Mocha was the great *entrepôt* of ancient commerce in the Red Sea between India and the West. But there were land routes also. Considerable trade was carried on by land conveyances and river navigation, especially from the Punjab as far as the Caspian Sea. Thence Indian goods were transported to Constantinople. Trade was maintained at Palmyra through the Euphrates valley, which is once more coming into importance by reason of our present occupation of Mesopotamia. We may pass over the first thousand years after Christ till the era of the Crusaders. After their retirement from Jerusalem, say, in 1187, St. Jean d'Acre, a seaport of Palestine, became their chief residence and the principal emporium of the Mediterranean, where the products of the East and the West were exchanged. Merchants from Venice, Genoa, and other commercial cities of Italy, were the great intermediaries. Constantinople thus became a great mart for all Indian goods, particularly the fine cotton fabrics. Marco Polo may be said to be the great pioneer who, having travelled to the Near and Middle East in the latter part of the thirteenth century, exhorted the European communities in south-eastern Europe to trade with the East Indies. The Venetians were the foremost to monopolise the Indo-Egyptian trade. They enjoyed this commercial monopoly till the fifteenth century, when Genoese power and commerce declined. Malacca, in the East. became also a great emporium, and the cities of Calicut and Cambay were particularly flourishing. Bengal cloths, especially the world-famous Dacca muslins, were in great request. Goods were carried from Cambay to the head of the Persian Gulf, and thence to Basra. From Basra, by navigation of the river and by caravans, they were conveyed to Aleppo, Damascus and Beyrout. There the Genoese, the Venetians and the Catalonians exchanged products and magnificently flourished. The other route was from Aden to Cairo. Lastly, other Indian merchandise was entirely carried overland by way of Kashgar and Balkh to the Caspian Sea, and even as far as the Baltic ports.

European Venturers of the Fifteenth Century.

The history of Portuguese and Dutch commerce with India may be passed over. Suffice to say that the two nations were the forerunners of the East India Company. The venturesome enterprise of the merchants of the days of good Queen Elizabeth was no doubt first stimulated by the argosies which the daring traders of the two nations took away from this country. These English merchants first established their factories at Surat, which, after the decline of Broach, was the great highway of commerce between the East and the West till Bombay eventually outstripped her and secured that hegemony which she is still enjoying in a remarkable degree. Besides Surat, Calicut and Maslipatam were also large centres of the export trade.

Early Modern Cotton Trade.

But throughout all these centuries, commencing with the establishment of the first factory in 1612 at Surat, cotton and cotton piece-goods formed the principal and most valuable export trade. The earliest mention of this raw material as an article of trade is to be read in Hakluyt's collection of voyages from a work called "The Process of English Policy," published in 1430. It is stated therein that "Genoa resorts to English ships which bring silk, paper, wool and cotton from India." It is generally presumed that Indian cotton reached the European countries *via* the Levant. The Levant trade was captured by the Dutch, after the Genoese. Beyond the Hakluyt collections, there was another book published in 1621 by one Mr. Munn, and entitled "Treatise on the Trade of India." In this work cotton was mentioned among other articles as imported from the Mediterranean. There is no doubt that England, before the discovery of America, was supplied with Indian cotton by the Levantine traders, the successors of the

Venetians in the trade of India. Mr. William Milburn, in his well-known compendious history of Indian cotton, relates that in 1641 it was stated that "the town of Manchester buys cotton wool in London, that comes first from Cyprus and Smyrna." This would lead us to infer that very little of the fibre at the time was imported from the West Indian Islands. A law was passed in 1660 prohibiting the landing of any cotton which was the growth of Asia, Africa and America except in the English dominions.

The following interesting statistics of cotton imported in Great Britain, on Mr. Milburn's authority, may be given:—

	In million lb.
Imported in 5 years, 1701 to 1705	5·854
,, ,, ,, 1716 to 1720	10·866
,, ,, ,, 1771 to 1775	28·822
,, ,, ,, 1776 to 1780	33·530
,, ,, ,, 1781 to 1785	54·709
,, ,, ,, 1786 to 1790	127·216

But even more interesting is the following table, which informs us of the cotton consumed in manufactures in Great Britain from 1793 to 1799, including the quantity imported from the East Indies:—

	In million lb.		
	East Indies.	Other ports.	Total.
1793 . .	0·760	18·059	18·820
1797 . .	1·353	21·820	23·174
1799 . .	6·934	36·279	43·213

Taking 1799, it may be further instructive to learn which were the countries whence England imported the largest quantities of the raw staple:—

	In million lb.
From Portugal	8·130
,, American States	7·170
,, British West Indies . . .	6·857
,, Asia (India)	6·934

Here are some figures of cotton imported from India by the East India Company in 1805, and by private individuals:—

1805.	In million lb.		£
East India Company .	2·769	valued at	157,000
Individuals	3·665	,,	228,000

The East India Company, from the commencement of the nineteenth century, were exceedingly keen on the improvement of cotton and the extension of its cultivation. The era of the steam engine and of the Arkwright spinning machinery had begun, and Manchester was thus favourably situated to forge ahead and compete with Indian-made cotton piece-goods. An idea of the extent of the exports, both of cotton and piece-goods, from Bombay and Surat in 1805 may be gathered from the following:—

Cotton valued at 85·67 lakh Sicca rupees.
Cotton piece-goods at 53·00 Sicca rupees.

The best cotton of that time was "Surat," a generic name for the varieties of the staple grown in the various districts of Gujerat, of which Surat city was certainly the great *entrepôt* of trade with the West. This appellation continued till "Dhollera" superseded it during the course of the great American Civil War of 1861–65, and thereafter, in its turn, "Broach" was considered as a class by itself of the finest quality, apart from "Fair Dhollera." It remains to be seen when, by the exigencies of trade, "Broach" may share the same fate as the other two, having regard to the notorious fact that the description generally known as "Broach" has also vastly deteriorated in recent years. However, "Surat," at the very beginning of the nineteenth century, held a supreme place among the spinners and weavers of Manchester, and it may, therefore, not be uninteresting to give a few facts as to what it cost, laid down in Liverpool. In 1805 the staple was selling at £22 10*s.* (calculated at 2*s.* 6*d.* exchange) per candy of 784 lb. The charges of conveyance to Bombay, baling and shipping, came to about Rs. 16 per candy, including merchant's commission at 5 per cent. And here two important items of charge, now bulking so abnormally high, namely, exchange and freight, may be considered. The balance of trade was no doubt in favour of India while Council Bills and other latter-day forms of remittance, so familiar to us all, were unknown. The ruling rate of exchange was 2*s.* 6*d.* per rupee against the average 16*d.* rupee of the opening days of the twentieth century. Freight, again, came to £22 per ton! This was payable at ninety days' sight after the arrival of the ship; while the rate of insurance was 7 per cent. on the value of the cargo. These facts as to Indian cotton at the commencement of the nineteenth century are now only of antiquarian interest. Still, they enable the modern trader in this commodity to realise the vast transformation that has taken place during a hundred years. The Surat cotton of old used to arrive in Bombay in native craft from Surat, Bhavnagar, Porebunder, Verawal, and other minor ports. Native craft still continues to ply in spite of railways and steamships. Whether it is a dhow, or a prow or a bugla, there it is, and can be seen any day riding at anchor in Mody Bay in the Bombay harbour. The pier where the cotton was landed was of a primitive character. It was even primitive, or only a little improved, during the stirring days of the American War. Apollo Bunder, as it was

called, was crowded to a distance, from the landing, of a couple of hundred yards with "docras," or unpressed bales. These had to be conveyed to the nearest cotton presses round about the custom-house in the Fort or at Colaba to be pressed and baled. But between the period of arrival and shipment a greater part of the cotton had to be warehoused and piled, also in primitive fashion, by a gang of coolies. The old bullock cart, still an institution in Bombay City, but destined in a few years more to be superseded by the motor lorry, was the only conveyance. It could accommodate only two docras. So an idea may be formed of the exceedingly laborious method of their haulage and final shipment in the old wooden ships. Cotton-ginning and cotton-presses have sprung up all over the country, more or less in the vicinity of towns where the raw staple is brought from the seats of production to be marketed. Their growth is nearly coeval with that of cotton-spinning and weaving factories, of which Bombay City and the city of Ahmedabad are the great strongholds. Hand-ginning of the rudimentary type known from time immemorial was the only method of separating the lint from the seed before the advent of the machine-gins and presses. It is still in vogue in distant villages, where those curious to learn all about the raw staple and its manipulation in this ancient country may see it at work. Indeed, many a process of cotton, from the first to the last, from ginning to spinning and weaving, all by manual labour, can be inspected in some of the villages where the hand-loom industry is still in a fairly flourishing condition.

Raw Cotton.

It is needless to observe that soil and climate have a great influence on the length and strength of the raw material. The Levantine species has little or no colour. The North American variety is white, the South American yellow, the Egyptian brown. In India all varieties may be obtained, according to the soil in which the plant is cultivated. Yellow cotton is held to be superior in point of fineness. Indian conservatism in matters of cultivation generally is well known, and cotton is no exception. The method of growing it is practically that which generations of agriculturists have followed, from father to son, from historic or even prehistoric times. Indeed, experts in Indian agriculture, invited from England and other countries of the West from time to time, have each and all been convinced that the Indian cultivator has very little to learn. No doubt intensive farming in a scientific manner might revolutionise the methods of cultivation in vogue. But that change demands as a precedent condition two important factors. Firstly, the comparative prosperity of the peasant; and, secondly, agricultural education on which the great civilised Governments of the West have spent and are spending enormous sums of money. Impecunious as is the average Indian cultivator of the soil, and plunged as he is in a morass of indebtedness, he cannot afford to apply the costly methods of intensive culture unless the Government comes to his aid in more ways than one. In the first place, agricultural credit and agricultural organisation have to be established. There are a few co-operative credit societies for helping the agriculturist; but at the best these are only a fraction of the immense number which are needed to supply the immediate pecuniary wants of the ryot if he is to raise his crop even in a single year. No doubt the Government has become alive to the necessity of agricultural credit, but only during the last fifteen or twenty years; and some progress may be witnessed later on, especially if the report which the Cotton Committee, who have now gone round the country, may make in reference to extended cotton cultivation and cotton improvement is accepted by the Government, and the recommendations they may make are practically attended to in a reasonable time. Secondly, the economic condition of the ryot, depressing as it is and far from prosperous, demands amelioration to a considerable extent. Until the ryot is lightened of his burden of annual assessments, which in the ryotwari tracts, especially the Presidencies of Bombay and Madras, are liable to revision every thirty years, it is hopeless to expect any amelioration in the pecuniary condition of the ryot.

Opinions differ on this vexed subject, as to whether the land revenue assessments in all parts of the country are or are not heavy enough, and whether the State does not absorb too large a measure of the product of the toiling peasant. There has been wrangling over this problem for the last fifty years at the least, without any definite conclusion. In this matter much might be learnt from the able minute of the late Sir Louis Mallet, written as far back as 1876, when he was Under-Secretary of State for India. One pertinent extract from the minute may be

quoted: "On the one hand, we see a system which sweeps into the coffers of the State 50 per cent. or more of the net produce of the soil, thus diverting a fund which, in countries where private property is absolute, would, to a great extent, find its way back again into channels of agricultural improvement. But the amount of produce thus diverted is not only large, it is also uncertain. The percentage itself is uncertain, varying with the views of successive Governments; and the amount actually assessed, even within the prescribed limits, is uncertain, varying with the accidents of seasons, with the character of the cultivators, and with the judgment and knowledge of the settlement service. . . . There is a marked absence of any adequate accumulation of capital upon the soil, and, as a consequence, of any sufficient appropriation of such capital to purposes of agricultural improvement, deficiency of stocks, of manure, of roads, of tanks, often of seeds, of implements."

Sufficiently serious attempts have not yet been made to diminish the burden of the ryot's heavy indebtedness, which hangs as a millstone round his neck. Agricultural relief legislation in the past, in some provinces, has been proved to be a comparative failure after many years' operation. The institution of agricultural banks with ample capital in each province can only relieve that indebtedness in thirty or forty years. But it is a matter of profound regret that the State has not as yet taken effective action with the object of diminishing this load of debt, which has been variously estimated at from 250 to 350 million pounds sterling.

So far, then, as to the ills from which the Indian peasantry has been suffering these many years past for want of a more active policy. Then there is the entity of the sowcar or money-lender. In reality, he is the saviour of the peasantry rather than the bloodsucker as he is generally represented to be, seeing that in the agricultural economy of the country he discharges a most useful function, in spite of his usury. One has only to imagine the sorry, nay, most pitiable plight in which the Indian peasantry might have been for years past but for the intervention of this most useful factor in Indian agricultural economy. Where would have been those larger exports of staple commodities but for the initial monetary assistance which the money-lender renders to the ryot; and where would have been the "growing" land revenue which is deemed the "backbone of Indian finance"? The fundamental relief lies in the direction of lightening the ryot's burden of revenue assessments, which are periodically enhanced for one reason or another, and the correctness of which unofficial experts, fully conversant with the condition of the peasantry, have repeatedly challenged. A prolonged and bitter controversy on the subject of taxing the improvements made by a ryot at his own cost raged in the Bombay Presidency some years ago.

Secondly, the institution of land banks, which could cautiously advance all the money needed for carrying on ordinary seasonal cultivation. With two such aids the ryot could diminish his cost of production and the interest charge on his debt, thus considerably improving his present most miserable economic condition.

And, thirdly, elementary education, especially in practical agriculture, which may prove highly useful to the rising generation of agricultural youths—an education which would enable them to realise how efforts by economy and labour-saving appliances could be made to grow two blades of corn or cotton where one is grown now. The moral duty of the State to give elementary agricultural education has been woefully neglected till lately; though it is some comfort to notice here the attempts which the Government of India has been making these few years past in reference to this subject. In short, the State in India has to take a leaf out of the book of the practical agriculturists of the United States and its Government in order to achieve the great object of extended and improved cultivation, not only in cotton, but in the many staple commodities which are so peculiar to India.

Cotton Cultivation.

It is not yet possible to state with certainty the actual area under cotton cultivation in India, though in recent times, thanks to the energy, industry and intelligence of the experts who have from time to time presided over the Statistical Department, there has been noticed a vast improvement in obtaining as accurate information as possible; and Mr. Findlay Shirras, the present Director of Statistics, has spared no pains to make his annual cotton forecasts reliable. It may, however, be said that, during the last twenty years, there has been a marked increase in the area of cultivation. Before the latest statistics for the current year are exhibited, a brief survey may be taken of the condition

as it was just a year or two before the American Civil War, which, it is superfluous to say, gave the first great impetus to cotton cultivation. In 1859 the exports amounted to 642,000 bales of 400 lb. each. Taking the yield, at the time, at 60 lb. per acre, the area then under cotton might be fairly computed at 4,280,000 acres. But this excludes the area then cultivated for home consumption. It is impossible to estimate the acreage, but it must be many lakhs. In 1864–65, the most critical year for the Lancashire cotton industry, the exports of Indian cotton had reached on an average 973,000 bales. This, at the rate of 70 lb. per acre, would give an area of 5,760,000 acres, an increase of 34 per cent. over 1859. Coming nearer to our own times, a fair idea of the area under cultivation may be gathered from a comparison of two periods, say, 1874–75, when cotton factories began to spring up in Bombay in larger numbers than at any time during the previous twenty years — the first factory was established in 1853 by an enterprising Parsi merchant, the late Mr. Cowasji Nanabhoy Davur—and 1888–89, when the acme was almost reached, after the continuous and steady growth of spinning and weaving mills in Bombay and Ahmedabad.

Area under Cotton Cultivation.

	In lakhs of acres. 1874–75.	1888–89.
Bombay and Sind	42·26	52·68
Berar	19·56	19·94
Central Provinces	8·05	5·96
United Provinces	10·87	13·05
Oudh	00·39	00·59
Punjab	7·10	7·56
Madras	15·77	14·65
Total	104·01	114·43

The increase amounted to over one million acres. This was exclusive of the acreage under Native States, for which reliable statistics are still wanting. The cotton crop estimates for 1917–18 may now be given, as the latest available. These are taken from the *Indian Trade Journal*, of which Mr. Findlay Shirras is the editor:—

Area under Cultivation and Yield per Acre.

	Acre in lakhs.	Yield per acre in lb.
Bombay, including Native States	66·70	74
Central Provinces and Berar	45·64	52
Madras, including Native States	25·24	79
Punjab do. do.	17·40	65
United Provinces do.	13·16	60
Sind do.	2·20	142
Burma	2·36	59
Behar and Orissa	0·67	95
Bengal, including Native States	0·71	113
Frontier Province	0·38	105
Assam	0·32	150
Ajmere-Merwara	0·47	111
Hyderabad	34·45	52
Central India	13·94	50
Baroda	8·27	105
Rajputana	4·27	80
Mysore	9·50	48
Total	237·68	Average 66

It will be seen that the average yield is 66; but the yield varies, going as high as 142 in Sind, 150 in Assam, and 113 in Bengal, and as low as 52 in Hyderabad and 60 in the United Provinces. It must be reserved to the Cotton Committee to fully explain the cause or causes of such variations, showing a maximum difference of 51 lb. The fact, however, shows that in certain provinces there is room yet for great improvement, albeit the average yield now obtained in India is low compared with that obtained in Egypt and the United States. Once the causes contributing to the comparatively poor yield are definitely investigated and ascertained, and remedies suggested whereby both the quantity and the quality may be improved, the cultivation of Indian cotton will leave little to be desired, though the problem of the extended cultivation of the long-stapled varieties will still remain to be solved.

Trade Descriptions.

Indian cotton, as far as exports are concerned, is sold according to the descriptions generally standardised by the chief cotton traders. These are "Oomras," "Dholleras," "Bengal," "Broach," "Westerns," "Coconadas," "Tinnevelly," and "Compta Dharwar." The Oomra descriptions have the largest acreage of all, and, therefore, the largest production of bales of 400 lb. each. The raw staple coming from Berar, Barsi and Nagar, from Khandesh, from Central India and from the Central Provinces—all these are included in "Oomras." Berar and Barsi yield the largest production; the number of bales for the former for 1917–18 are given at 4,28,000, and for the latter at 4,41,000. The Dhollera varieties are estimated at 5,98,000; the Bengals, including those from Sind-Punjab, at 7,05,000 bales, and Broach at 3,20,000 lakh bales. The total is estimated at about 40 lakh against 44 lakh in 1916–17.

Exports.

The bulk of the Indian cotton is exported to Japan. The share of Japan during the five years ending 1913–14 averaged 42 per cent. of the total exports. Germany's share came to 14·5, and Belgium's to 11·5 per cent. The United Kingdom only imported 5 per cent. In 1917–18, Japan's share came to as much as 68 per cent. while Italy's was 11·4, and the United Kingdom's 9·4 per cent. Prices have undoubtedly mounted higher and higher while the quantity of exports has somewhat decreased, say to 425,000 tons against the average of 430,000 tons ending with the quinquennial period from 1909–10 to 1913–14. The values as recorded are for an average of five years ending:—

		Millions £.
1913–14 =	33·27 crore rupees =	22·18
1915–16 =	24·92 ,, ,, =	16·61
1916–17 =	34·18 ,, ,, =	22·72

Cotton Factories.

Calcutta claims the honour of having established the first cotton-mill in India. The Goosery mill was erected in 1838, but for many years nothing was heard about its working. For all practical purposes, it may be fairly said that the first foundation of the producing of yarn and cloth by steam-power was laid by Mr. Cowasji Nanabhoy Davar, to whom I have already referred. He was also the pioneer of what may now be called *swadeshi* ! (indigenous) banks in India, and he built the first ice factory in Bombay. His bank, which was called the "Central Bank of Western India," took its birth in those stirring days of the American Civil War when, flushed with the large profits in cotton, a variety of banks and financial institutions sprung up in Bombay only to come to grief soon after the close of that war in 1865. Mr. Cowasji started his cotton-mill with only 5,000 throstle spindles. As a youth the writer saw it in 1856, when it was in full working order and yielding a handsome profit to the owner. The mill is still standing, albeit greatly enlarged. About the same time an Englishman, Mr. Landen, is said to have started a small factory in Broach, but nothing much was heard of it for some years, when it developed into a fairly large mill. Mr. Cowasji may therefore be rightly considered the founder of the cotton industry in India, and his name deserves to be perpetuated for the great impetus his enterprising talents, his patience and perseverance gave to it. Between 1853 and 1874 the number of mills rose to nineteen in the Island of Bombay; but till that period it is not known that a single cotton factory had been established elsewhere, save one or two in the city of Ahmedabad. The earliest of the Bombay mills were the Oriental, the Manekji Petit, the Alliance, the Great Eastern, the Coorla, and the Morarji. Excepting the Alliance, all were spinning and weaving mills. Their founders, shrewd men of business as they all were, and more or less importers of Lancashire piece-goods, from the very first had clearly realised the importance of manufacturing cloth suited to Indian consumers. The great rise in the price of the raw material, which had reached the phenomenal figure of Rs. 600 per candy, had the blighting effect for the time of suspending work, it being impossible to manufacture cloth of the coarser descriptions only at the enhanced price of cotton. In fact, the early mills had to shut down till some time after the restoration of peace in the United States, when, of course, the price declined to normality. The revival of trade and credit in Bombay, which had been at its lowest for the first five years after the collapse of the share speculation, somewhat akin to that of the South Sea Bubble mania, soon led to the capitalists embarking on the cotton industry, which they quickly realised was most profitable and suited to the conditions of the rising city. It was also seen that there was a considerable field for their enterprise in areas bordering on the cotton-producing districts. Mr. J. N. Tata was the very first to seize the opportunity of establishing a factory at Nagpur, and he was closely followed by Mr. Morarji Goculdas at Sholapur. The Empress Mill, Mr. Tata's concern at Nagpur, started working on January 1st, 1877, and the name had its origin in the proclamation on that day of Queen Victoria as Empress of India. The opening of this and the establishment of the Sholapur Mills were events of no little importance in the industrial annals of the country, as they were really the pioneers of cotton-mills outside Bombay. They paved the way for the establishment of many mills, first in the Presidency of Bombay, notably Ahmedabad, and later in other parts of India, chiefly in the cotton-growing districts. But this rise of mills in the seventies seems to have alarmed Lancashire. Locally-made yarns, chiefly of 20' counts and those below it, had been considerably displacing Lancashire, so also some of the coarser descriptions of grey goods such as T. cloths and Domestics. Hence Manchester succeeded, in

1877–78, in getting the House of Commons to pass a resolution to the effect that "in the opinion of this House, the duties now levied upon cotton manufactures imported into India being protective in their nature, are contrary to sound commercial policy and ought to be repealed without delay as soon as the financial condition of India will permit." Famine conditions of a severe character then generally prevailing in the country prevented the Government of India and the Secretary of State from carrying out the resolution. But on March 13th, 1879, the first step in the ultimate repeal of the import duty on cotton goods from Lancashire was taken. The repeal, it may be stated. was first mooted in 1875 during the Viceroyalty of the late Lord Northbrook, who, however, refused to adopt the policy suggested by Lord Salisbury, the then Secretary of State. Even in 1879, the financial condition was far from prosperous. The country, in the first place. had not yet emerged from the effects of the famine conditions which had prevailed during the preceding two years, and, in the second place, the Second Afghan War had considerably embarrassed the Indian treasury, and a huge deficit was afterwards discovered. The repeal in 1879 was confined to the coarsest class of Lancashire grey goods, the amount which the Indian revenues had to sacrifice being £25,600. This repeal did not satisfy Manchester. The resolution passed on March 13th, 1879, was to the effect "that the Indian import duty on cotton goods being unjust alike to the Indian consumer and the English producer, ought to be abolished, and the House accepts the recent reduction in those duties as a step towards that total abolition to which Her Majesty's Government are pledged." The finances of the country were so greatly disturbed by the Afghan War that nothing could be done till 1882–83. Lord Ripon, a staunch Free Trader, was the Viceroy, and Sir Evelyn Baring (the late Lord Cromer), also a robust Free Trader, was the Financial Member. They both made India a free trading country, having abolished all import duties, including those on piece-goods.

At the date of the repeal of the duty on the coarser kinds of Lancashire piece-goods the number of Indian cotton-mills had risen to 58, and there is no doubt that the abolition of all duties, in 1882–83, gave a great stimulus to the multiplication of cotton factories in the country. Practically the eighties of the nineteenth century witnessed the largest number of new mills, not only in Bombay but elsewhere. The number, which was only 58 in 1878–79, rose in 1888–89 to 114, say an increase of 64 mills, of which no less than 29 were established in the city of Bombay alone. The spindle strength increased by 1,200,000 and looms by 10,385 :—

	No. of Mills.	Spindles.	Looms.
1888 . .	114	24,88,851	19,496
1878 . .	58	12,89,706	9,111

The momentum which the industry acquired in that epoch-making decade continued, with more or less force, till the outbreak of the present war. The progress from 1889 to 1914 will be seen from the following :—

	Spindles.	Looms.
1914	67,78,895	1,04,170
1888	24,88,851	19,496
Increase .	42,90,044	84,674

Within a quarter of a century India's spindle power has increased 172 per cent., and loom 434 per cent. In 1916, the spindles had increased in number over those of 1914 by 60,892, and the looms by 6.089.

Thus during the last forty years and more India has undoubtedly forged ahead in placing the industry on a sound and prosperous footing. But great as this accession to her spindle and loom strength is, it is needless to state that it is far below that of the United Kingdom. The following figures show how, in the competitive race of the cotton industry, the United Kingdom is immeasurably far in advance of India.

1916.	Spindles.	Looms.
United Kingdom .	5,98,11,222	8,08,796
India	68,39,877	1,10,268

How do Great Britain and India stand in this respect in comparison to their respective populations?

	Spindles. Per 1,000.	Looms. Per 1,000.
United Kingdom . .	318·2	17·8
India	21·7	0·35

These figures plainly show that it will be a long long while before India can hope to boast of the strength which Great Britain now enjoys in the cotton industry. And while that is the case, and while the long-stapled variety of cotton is yet as far distant from realisation as it was fifty years ago, it may be reasonably inquired whether India can displace the enormous import of piece-goods, which at the end of 1914–15 amounted to 2,420 million yards, valued at £28·4 million.

But at this stage it is essential for the purpose of a clear comprehension to exhibit the figures of the production of yarn and cloth, say, for

the quinquennial period which ended March 31st, 1914, and for the triennial period which ended March 31st, 1917.

	Yarn in core lb.
1912–13	68·84
1916–17	68·05

There is a diminution of 79 lakh lb., which may be deemed almost negligible. The production has fluctuated, but has not again reached or surpassed the figures of 1912–13. At the same time, part of the diminution is owing to the spinning of higher counts. There has been an increase in the production of higher counts to the extent of 2·29 crore lb. between 1914–15 and 1916–17, whereas in the lower counts, say, from 1 to 20, there has been no increase to speak of. This will be clearly perceived from the following comparative table:—

	In crore lbs.		
Low counts.	1914-15.	1915-16.	1916-17.
1 to 10	13·10	14·53	11·06
11 to 20	34·33	38·62	36·95
	47·43	53·15	48·01
Higher counts.			
21 to 30	15·62	16·97	17·14
31 to 40	1·87	1·86	2·40
Above 40	0·22	0·19	0·46
	17·71	19·02	20·00

It should be noted that it is more or less due to the larger demand of 30's, the imports of which have considerably dwindled, with higher prices, that Indian mills increased their output, and not for purposes of weaving, which is still next to nothing. This will be seen from the following figures:—

	In crore lbs.		
	1914-15.	1915-16.	1916-17.
English (mule and water), 26 to 30	0·47	0·32	0·09
Indian, 30	1·96	2·04	2·32
English, 41 to 50	0·29	0·27	0·13
,, 50 and above	0·28	0·30	0·19
Indian, 40 and above	0·22	0·19	0·46

When the Lancashire mills are again in full swing after the war, it may be taken for granted that Lancashire yarns from 30's and upwards will largely overtake the Indian production. It is well known that hand-loom weavers, who are the largest consumers of English 30's, prefer the English to the Indian on account of its great superiority. It should also be remembered that the exports of Indian yarn have been declining since 1913–14. The reduction is as follows:—

	In crore lb
1912–13	20·39
1913–14	19·80
1914–15	13·36
1915–16	16·02
1916–17	16·04

What the Indian mills have lost in the exports of yarn has been made up in the exports of cloth. In other words, more yarn has been woven into cloth for home consumption and foreign demand. There is nothing very extraordinary in this condition of the Indian industry. Apart from China, the largest importer of Indian yarn is Persia, where the quantity imported from India during 1916–17 was 51·08 lakh lb., against only 17·67 lakh lb. two years ago. Minor countries have also been large absorbents. Their imports during 1916–17 came to 65·64 lakh lb., against 26·28 in 1914–15. Japanese yarn is undoubtedly fast replacing Indian in China, and it is quite possible that within the next few years Indian exports to that country will be more or less negligible. It is to be presumed that India will have a larger market after the war in Asiatic Turkey, and new markets in East and West Africa. But the larger the quantity of indigenous yarn that is consumed in the manufacture of cloth, the less will be the exports to the new markets unless the production is greatly stimulated. That will largely depend on the extent to which India increases her spindle strength after the war. Indian mills, which are now reaping a rich harvest of profits, are wide awake, and the more sagacious and well-financed are carrying large reserves to depreciation and renewals of machinery to meet future requirements.

Coming to the production of piece-goods, mostly grey and dyed, it may be observed that till 1907 the number of power-looms in all India was only 58,436. But there was a considerable spring forward in 1908, as many as 9,484 looms being added. This brought the total to 67,920, till in 1910 it reached 82,725. In 1912 it was 88,951, and in 1916, as already pointed out, it was 1,10,268. Thus in nine years the loom power has increased nearly 90 per cent., while there is little doubt that the post-war period will witness a considerable accretion. Of the increase of 51,832 looms in all India, the share of mills in Bombay City alone come to 21,223, that is to say, against 31,982 in 1907, there were 53,205 in 1916, the balance of 30,609 being distributed over all the other parts of India.

The annual average of cloth production in the Indian mills during the decennium ending 1910–11 was 16·45 crore lb., but in the last year the figures recorded were 23·09 crore lb. In 1911–12 the output rose to 25·21 crore lb., while the production since was as below:—

	In crore lb.
1913–14	27·44
1914–15	27·70
1915–16	35·22
1916–17	37·73

The production during the last three years has mounted up to 37·73, say an increase of 10·03 crore lb.

It is, however, necessary at this stage to analyse the output in its two-fold aspects. Indian cloth may be divided into two broad divisions, namely, grey and coloured piece-goods. Bleached goods are yet in their infancy, but there is a great potentiality in these, as the more important factories have bleaching plants on a scale which will commercially pay. There is only one such fully equipped in Bombay City. A few others have bleaching plants, but for all practical purposes they are negligible at present. The output of the two groups may be exhibited for the latest triennial period, ending March 31st, 1917, as under:—

	In crore lbs. Grey.	Dyed.
1914–15	21·36	6·10
1915–16	26·72	8·16
1916–17	27·46	9·82

The increase in the output of grey goods was 6·10 crores, equivalent to 28·5 per cent.; while that in dyed goods was 3·72, equivalent to 61 per cent. This plainly indicates that the coloured stuffs have made in the triennium highly gratifying advance. The rate of the progress was double and a little more over that of grey. The reason is not far to seek. Owing to the diminishing imports of dyes from Germany, the market for anilines and alizarine colours began slowly to rise till at last fabulous prices were demanded by the handful of traders in dyes. This led to a keen scramble to buy, and speculators forced prices up. Indeed, the dye trade in Bombay City was for a time a pure gamble, and the man in the street who sometimes tried his luck with a few rupees in his pocket would often end the day with a heavily-laden silver pocket. Public opinion, however, denounced this speculation and it died away. The mills bought all that could be had, while the profiteering traders managed to conceal their stocks, thus creating an artificial scarcity in order to further inflate the prices. But in spite of the enormous prices per pound at which mills acquired the principal colours, there was such a keen demand for coloured goods, by reason of the material decline of imports from Lancashire, that the output of dyed goods in Indian mills rose to phenomenal figures, while the profits earned were equally phenomenal. In this respect the following table is most interesting. During the last year of the pre-war period the imports of English dyed goods was 68·22 crore yards and the output of Indian mills 30·62:—

	In crore yards. 1912-13.	1914-15.	1915-16.	1916-17.
English Grey Goods . .	153·61	129·46	109·90	76·20
Indian Grey Goods . .	91·41	88·05	109·48	113·48
English Coloured Goods . .	68·22	46·36	32·25	40·37
Indian Coloured Goods . .	30·62	25·52	34·66	44·16

This table tells most eloquently the effect of the decline of the imports of Lancashire grey and coloured goods in India and the increased production of the grey and coloured goods in Indian mills.

	Per cent
(1) English grey goods imports declined	50·3
(2) English coloured imports declined .	41·0
(3) Indian grey goods output increased .	24·1
(4) Indian coloured output increased .	44·2

I now turn to the second aspect of the comparative analysis, namely, descriptions of grey goods. Here it should be explained that Indian mills produce some varieties, such as grey "chadars," which are not imported into India. Again jacconets and mulls imported from Lancashire are hardly produced in any quantity at all. And as to coloured goods, Lancashire exports a variety such as cambrics, madapollams, muslins, mulls, jacconets, dhutis, drills and jeans, saris, shirtings, twills, printers, etc., of which Indian mills only produce checks and perhaps a few negligible varieties. So there can be no manner of comparison between the coloured goods imported and those manufactured in the country.

ENGLISH GREY GOODS.

	In crore yards 1913-14.	1914-15.	1915-16	1916-17
Dhutis, Saris, and Scarves . . .	80·60	66·62	61·00	52 00
Drills and Jeans .	00·96	00·69	00·40	00 35
Longcloth and Shirtings . .	53·98	50 23	38·19	15·53
T. Cloth . . .	00 63	00·45	00 22	00·01

INDIAN GREY GOODS.

Dhutis . . .	28·47	25·90	32·36	30·09
Drills and Jeans .	2·78	3·08	4·63	5·65
Longcloth and Shirtings . .	29·25	32·07	41·96	42·65
T. Cloth . . .	12·89	13·42	15·14	19·22
Cambrics . . .	00·50	00.35	00.57	00·63
Chadars . . .	6·78	6·56	7·51	6·77

The class of goods in which there is a marked increase of yardage is longcloths and shirtings. English imports before the outbreak of the war totalled 539 million yards, and by 1916–17 these had declined to 155 million yards. Meanwhile Indian-made longcloths and shirtings,

which were 292 million yards in 1913-14, had risen to 426 million yards. It must be remembered, however, that quality for quality Indian longcloth is not identical with the English. It is well known that the former is made from 24's weft and 22's warp. The English is of higher counts than these. It may be that here and there some mills are turning out the same quality as the English, but it will be found on accurate investigation that the quantity produced is perfectly negligible.

It is not the object of this paper to enter into the vexed controversy of protection and substitution in connection with the import duties. That controversy must be decided on its own merits and on the basis of ascertained facts. But this much may be stated here that Lancashire's apprehension about the competition of Indian mills in the description of the greater bulk of grey, white and coloured goods is unfounded, for the simple reason that India has not yet been able to provide herself sufficiently with long-stapled cotton from which the goods could be manufactured. Rather Lancashire should be apprehensive of the strides Japanese goods are making in the common market of India where Lancashire exports her goods. Japan has the great advantage of using American cotton for her cloths, and her mills have for some time past been steadily pursuing a policy of turning out goods of Lancashire descriptions to sell side by side in the Indian markets. Here are some figures:—

IMPORTS FROM JAPAN.

	In crore yards. 1913-14.	1916-17.
Drills and Jeans . . .	0·17	1·01
Jacconets	—	0·22
Longcloth and Shirtings	0·53	2·91
Shirtings	—	3·41
White Drills and Jeans .	—	0·17
„ Longcloths . .	—	0·04
Coloured Checks . . .	0 05	0·44
„ Drills and Jeans	0·01	0·38
„ Shirtings . .	—	0·16
Unspecified	0·09	1·17

In 1912-13 the total imports of piece-goods from the United Kingdom and foreign countries were 298 crore yards, while that produced by the Indian mills came to 122 crores—in all, 420 crore yards. In 1917, owing to the sharp decline of Lancashire imports, the total came to only 189 crore yards. But the Indian mills produced 158 crore yards, so that the total reached 347 crore yards. This was 73 crore yards less, while the population meanwhile has been greatly on the increase. Practically, taking the census population at 31 crores, there were 13·55 yards per head, against 11·20 in 1916-17. Of course, the production of handlooms, an unknown quantity, should be added to these quotients.

CONCLUSION.

At the end of March, 1917, there were in India, including Native States, 266 cotton-mills, of which 85 were situated in the city of Bombay, 94 in the Bombay Presidency, 18 in the United Provinces, 14 in the Madras and 14 in the Bengal Presidencies, 7 in the Central Provinces, 7 in the Punjab, and the rest scattered in the other provinces. Their combined capital aggregated 19·63 crore rupees, say, 13·08 million sterling. Of this 7·95 crore rupees belonged to Bombay City, and 4·68 crores to the various towns in the Western Presidency. Beyond this share capital, it may be assumed, at a conservative estimate, that 10 crores more were invested as loanable capital for working purposes, so that the combined capital might be taken at 31 crores, or £20 million. The total number of spindles was 68·40 lakh, and that of looms 1·10 lakh. The number of workpeople employed was recorded at 2·74 lakh, which signified that 8·22 lakh persons lived or depended on the wages earned by the operatives. Their wages, on an average, would come to about £3·2 million per annum. The total number of cotton bales, of 392 lb. each, consumed by the mills was 21·97 lakh.

Judged by the broad statistics indicated above, it will be admitted that the Indian cotton industry has made, during the course of the last fifty years, steady and substantial progress, which is as creditable to the enterprise, energy, and mercantile acumen of those engaged in the industry, as it is gratifying to the population at large, who are keenly interested in the greater development of all kinds of industries in the country on sound and prosperous lines. The progress made in the cotton industry is an earnest of the strides it may take in the future, perhaps, at a quicker pace than has been the case hitherto. As in other economic matters, so in this, the war has made us unlearn many things and learn many more, and it is quite possible that in some respects the Indian millowners will take a new departure after the lessons the war has taught.

Here it is needful to take into consideration two external factors of a potential character,

which have partially obstructed the larger progress which might have been fairly expected. These are, firstly, the Japanese competition, and, secondly, the political influence of Lancashire. Apart from pushing a variety of her products and manufactures, Japan has taken a bold step forward in placing on the Indian market her cotton fabrics, especially those made from Indian cotton purchased in India. There has been a very large import of unbleached calico, as a beginning only, since 1912–13, as will be evident from the comparative table below:—

	1912-13. £	1916-17. £
Cotton Hosiery . .	415,000	850,000
„ Piece-goods .	73,000	1,621,000
„ Yarn . . .	35,000	354,000
„ Sundries . .	16,000	217,000
	539,000	3,042,000

An increase of from half a million to three million sterling in the short space of four years tells its own tale of the strides the Japanese industrial giant has made. Of course, the leaders of the Indian cotton industry say that so long as the British Government refrains from placing an export duty on the raw cotton which Japan buys from India, averaging in value about £12 million, the Indian cotton industry is placed at a great disadvantage. It might have been a different story had Japan grown her own cotton from which to manufacture her fabrics and export them to India for competition with Indian cotton products. But such is not the case. The bulk of her yarn and piece-goods is manufactured from cotton bought in India. She has already replaced in the Chinese market more than half the quantity of yarn which India used to export ten years ago. And she is strenuously endeavouring at the present time to push her cloths. That is the prime factor involved in the unequal competition. Next is the question of freight. The freight is of a two-fold character—freight for the conveyance of the raw material to its destination, and freight for the transport to India of the manufactured cotton goods. The cost of such double freight would ordinarily prevent any manufacturer from competing with Indian cotton goods. But in the case of Japan, the freight to and fro is believed to be subsidised. Thus the cost of production stands on a par. Of course, the Japanese have some local advantages, one being cheaper labour, though even in Japan labour is becoming more expensive. The difference is not in the wages of the operatives. These are almost equal. The average wage earned by a Japanese male operative is 12½ annas, by a female 8¼ annas, per day. But the proportion of male to female workers is just the opposite of what is generally the case in India. In Japan, the percentage of female operatives to males is as ¾ to ¼. Necessarily the cost of wages is advantageous to the Japanese spinner compared to the Indian. There are other minor advantages, for example, the daily average working hours come to 22·16, while the monthly average working days are 27·25. Necessarily the daily spindle production is greater. But all the local advantages do not and cannot outweigh the immense saving in freight. Practically, cotton is moved free to Japan, and cotton goods are transported back to India free, or almost free. There are those who, carefully watching the present triangular character of the competition prevailing in India, do not hesitate to forecast the probability of Lancashire goods having to bear the stiff competition of Japan in the Indian markets. For, since the war began, there is to be noticed the unusual phenomenon of Indian, Japanese and Lancashire piece-goods struggling to make a headway. The struggle is yet at its beginning. But Japan has only by a variety of methods to push these goods, even at a loss for a time, till she has obtained a strong foothold in the country. That there is every reason to believe that she will gain such a foothold goes without saying. Under the circumstances, it may be asked whether it is not Lancashire's interest to see that it is not slowly driven away from some of its best markets in India. Some Indian politicians have more than once suggested an export duty on cotton, but thinkers of the opposite school assert that such a duty would greatly disadvantage the Indian ryot. An export duty on cotton by cheapening the raw material might discourage the Indian cultivator, and induce him to substitute other crops, thus reducing the total available supply of cotton. If, however, there were to be a growing demand from Great Britain for it there could be nothing to prevent India extending her area for this material, seeing she must be taken now as an integral part of the British Empire. The whole problem of an export duty no doubt bristles with difficulties which, it is to be hoped, fair-minded British statesmen who mean well to India, and who are sincerely desirous of advancing her commercial and Indian interests, will attempt to solve to the satisfaction of the Indian people. Otherwise foreign industrial

penetration now springing up might grow to gigantic proportions in the future, prove vastly detrimental alike to Indian and Lancashire interests, and be most difficult to overcome later.

The second external factor which has somewhat hampered the progress of the Indian cotton industry is the action Lancashire has from time to time taken in reference to import duties, excise and the introduction of factory legislation. Attached to no party and interested only in the greater welfare of Indian cotton industry, the present writer ventures to make the following observations in a spirit of the utmost fairness and candour. He is himself a convinced Free Trader, and on many points is generally in agreement with the views of Manchester. The men of Lancashire are perfectly aware of the opinion entertained, not only by Indian millowners, but by the enlightened section of the entire Indian community, that whenever occasion demands they are not backward, by reason of the great political influence they command in the House of Commons, to press their own wishes on the Government at home in matters where they apprehend their special interests are at stake. This kind of pressure, it is urged, has been more than once exerted during the last forty years; which, in the opinion of the Indian millowners, has been most prejudicial to the interest of the great industry in which they are engaged. The steady and substantial progress which the Indian cotton industry has continued to make since 1880 might have been greater but for this pressure. Indian millowners are convinced that the pressure is exercised because of the apprehension, if not the alarm, felt by Lancashire about the material curtailment of its piece-goods trade in the Indian market as cotton-mills grow in number and in the strength of the spindles and looms. The apprehension, say the Indian millowners, is natural, but they seriously doubt whether the method and manner adopted by Lancashire are justifiable, namely, using their great political influence in and out of the House of Commons to urge Ministers, be they Liberal or Conservative, to ask the Indian Government to enact legislation or issue executive orders under the pretext of maintaining the Free Trade policy of the Government at the seat of the central authority or of sanitary benefits for the Indian operative. They question the sincerity of the interest evinced in Lancashire in the welfare of Indian factory operatives, and are disposed to attribute it to a desire to restrict Indian competition. They give instances. The first of such agitation was started in 1875 to abolish the 7½ per cent. import duty on all cotton goods. It was negatived by Lord Northbrook, who declared that the duty was levied for revenue purposes only and the protection theory did not exist. In those days, it is very well known, Indian finances were extremely poor and the sources of revenue exceedingly inelastic. The 7½ per cent. duty was imposed on almost all classes of commodities, including piece-goods. But Lancashire continued the agitation and was able to have the duty removed from the coarser classes of goods in 1878-79. Lord Ripon and Sir Evelyn Baring abolished all import duties except on liquor and arms, in 1882-83. So the agitation against protection died out for a time. But the eighties of the nineteenth century were a memorable period in mill construction. Lancashire was alarmed, so another cry was taken up, namely, the necessity of a Factory Act. It is superfluous to go into the history of that agitation. Suffice to say the enormities alleged against the inhumanity of Indian millowners were carefully investigated by an impartial commission, who proved that most of the so-called facts of the agitators were baseless. All the same, a Factory Act was passed in 1890, regulating the hours of labour and the employment of young persons and women. The Indian millowners have not forgotten that Lancashire agitated for shorter hours in Indian mills. They think the motive was less philanthropy than the curtailment of production. Their impression may be wrong. But there it is.

Subsequently, the closure of the mints and the low exchange, creating a deficit in the revenue, necessitated the reimposition of the import duties. Still later on, the duty on piece-goods was differentially treated, and it was fixed at 3½ per cent. only, while other commodities were dutiable at the rate of 5 per cent. This differential treatment was universally condemned by Indians. Moreover, the plea of protection was again vigorously raised, and under the pressure of Lancashire there came the mandate from the Home Government to impose a countervailing excise duty on Indian-made cloths to appease the Palatine County. The millowners of Bombay strongly protested against the injustice of this imposition by cogent arguments, which have lost none of their force even to-day. The Government acted wisely in levying the new import duty of 7½ per cent. on Lancashire

piece-goods last year, and by doing so have frankly admitted that the former duty was unjust to India. But the Indian millowners still consider that the excise duty of 3½ per cent. ought to go, seeing that it in no way serves as a protection to them against Lancashire goods. The last conviction, which also has a firm hold on the minds of those engaged in the cotton industry, is that the revised Factory Act passed a few short years ago was the result of the self-same pressure which has distinguished Lancashire so far as her trade in piece-goods with India is concerned. It is for Lancashire to remove, if it can, these deep-rooted convictions. But, meanwhile, the opinion is general and strong that all the four episodes above referred to in the cotton industry have to a certain extent hampered the steady progress it has been making since 1880. Thus Japan and Lancashire are considered the two external factors of a most potent character against the further natural development of the Indian cotton industry.

On the other hand, it may not be unuseful to refer to some internal factors also which, in the opinion of the present writer, impede the smooth progress of the industry. These factors are of a twofold character. Firstly, the action of the Indian State in relation to commerce and industry by means of legislation and the pressure which the State brings to bear on owners of cotton factories to undertake primary education for the young operatives and to provide sanitary dwelling-houses for the workers in general. As an instance of the first class of internal factors may be cited the Indian Railways Act of 1890. This enactment has long been the subject of agitation, on the ground that it is one-sided and arbitrary in respect of transport of foreign goods inland. and also in respect of long and short distance freights, which are generally complained of as hampering the free working of large trades and industries. Dissatisfaction in this respect has led to a strong agitation for the complete management of all State-owned railways by the State. The Government has recently invited all important commercial and other public bodies to send in their suggestions as to how far and in what directions the Railway Act can be amended. The other interference of Government has for its object humanity. It is to provide sanitary dwelling-houses for the working-classes. Mill-owners hold that this is a duty of the State, and not of the employers. But the Indian Government has for some time past been mildly coercing employers in the cotton industry *in the city of Bombay only* to provide that accommodation, at the same time expressing its readiness to co-operate with them. But when it comes to the specific nature of the co-operation, it is nothing but a temporary financial arrangement to enable millowners to acquire the needed land, the cost of which has to be repaid by them by instalments, with interest on the sums advanced. In this way the State tries to impose its authority on the millowners and partially hampers their proper working. Of course, it goes without saying that millowners in their own better interests may provide sanitary dwelling-places for their operatives. But it is one thing to do such a work voluntarily and another thing to be compelled to under State coercion. It is this kind of interference to which Bombay millowners object. They ask whether Lancashire millowners are coerced in this fashion by the British Government. There is, again, the education of operatives. The Bombay Government has been off and on urging on the millowners to discharge a duty which throughout the civilised world is undertaken by the State. It is not the legitimate business of millowners. Here, too, there is an interference which is disliked, though, of course, it is no hindrance to the working of mills. The millowners in both cases do not deny their moral obligation. They are ready and willing to co-operate with the Government, and even to contribute their quota, but it is unheard of that such duties in any way belong to those engaged in the cotton industry. Moreover, it is a matter of astonishment that Bombay millowners alone should be thus pressed, seeing that there are only eighty-five mills in the city, or only one-third of the number in all India.

It remains to be seen how, at the close of the war, Indian industries of a variety of character take a new departure. The economic lessons which the war may teach will be of the highest import for the future progress and prosperity of the cotton-mills, as well as for their operatives, who are now beginning to understand their rights and responsibilities, and all about the advantages of higher wages accompanied by shorter hours. They are also growing self-assertive, while their leading men are not slow to acquaint them with the future relations of Capital and Labour. But whatever may be the new departure, it may be taken for granted that the Indian cotton industry has a great future before it, and given the necessary im-

provements still lacking in the internal management, and a better insight into the general industrial problem of the world, a broader view of international trade and of new markets to be tapped, there is not the least doubt that Indian mills will take larger and more satisfactory strides in the future. Millowners will be wise, therefore, in their own interests, to put their house in order from now, so as to be prepared at the proper hour to make a cautious but bold spring forward. It is a settled conviction with them that India can economically prosper only when she is mistress in her own house, and able to carry out her own fiscal independence without any of those bonds and fetters which hitherto have circumscribed her efforts in various directions. There is the growing patriotism to work India in the interests of the Indians themselves. Such a spirit is most likely to evolve changes undreamt of hitherto. But whatever may be the changes, it is to be hoped that Lancashire will try to understand India better than it has hitherto done, in a spirit of the greatest comradeship rather than of any unhealthy rivalry; and that on the other hand India will in an equally friendly way endeavour to learn many lessons in the cotton industry which Lancashire alone is capable of teaching.

[The paper was read, in SIR DINSHAW WACHA's absence, by SIR CHARLES H. ARMSTRONG, late Chairman of the Bombay Chamber of Commerce.]

DISCUSSION.

THE CHAIRMAN (The Right Hon. E. S. Montagu, M.P.) said that the paper had given an interesting historical retrospect of the development of the cotton industry in India from ancient to modern times, but it was with the latter that practical men were primarily concerned to-day. Everyone knew that cotton, like most other things, had always presented controversial questions, and while he had no complaint against the comments that Sir Dinshaw had made on Government action in the past as a subject of legitimate controversy, it would be understood that he took no responsibility for the author's opinions. As one who had long been engaged in political controversies, there were many points on which he would be prepared to take up the challenge, but he proposed to leave that task to others whose practical acquaintance with the cotton industry was greater than his. Only a few days ago there was published as a Parliamentary paper the report of Sir Henry Birchenough's Committee on the Textile Trades after the War, and no doubt many of the audience had read that section of the report which dealt with cotton. The Committee was gravely concerned with the future of cotton supplies, and regarded it as eminently unsatisfactory that one of the principal industries of the United Kingdom should be so largely dependent upon one source of supply, and that a source entirely beyond its control. They regarded it as reasonably certain that all cotton required by the British Empire could in time be grown in its own territories, and of all sources of supply, actual or potential, they regarded India as offering the most promising prospects of any considerable increase of output within a reasonably short time. It might be that, in so far as the supply of long-stapled cotton was concerned, India might fail to satisfy in full these expectations, but that the yield of cotton per acre in India could be increased seemed beyond doubt, and it was also, he hoped, reasonably certain that if the proper measures were taken she could become a more important source of supply of long-stapled cotton than at present, and that the cultivator might be able to look forward to an adequate price for his superior cotton. It was satisfactory that the Government of India, when they received the report of Sir Henry Birchenough's Committee, immediately took the matter up in earnest, and appointed last year a committee to inquire into the whole question. The committee, which was presided over by Mr. MacKenna, Agricultural Adviser, and which included technical experts in India, Mr. Wadia, of Bombay, and Mr. Hodgkinson, of Blackburn, was about to submit its report to the Government of India, if that had not already been done, and it was to be hoped that it had been able to recommend practical measures to secure the object in view. As a producer of cotton, India occupied the most important position in the Empire, and everything possible must be done to secure and improve that position. In this respect, at all events, the interests of India and Lancashire were not antagonistic, and the Government of India had appointed a representative of Lancashire to the committee. The association of Lancashire in an Indian inquiry of that kind could not fail to be beneficial to both sides and it was not too much to hope that each might thereby have been enabled better to appreciate the needs and difficulties of the other. Not the least interesting portion of Sir Dinshaw's paper was his description of the changes in the Indian cotton industry that had been brought about by the war. In one respect the effect of the war had been of special interest. The supply of British-made goods having fallen off, owing to shipping difficulties and other causes, it was necessary to fall back on the Indian mills for Army supplies, and it was gratifying that the cotton textiles required for Army purposes were now being manufactured entirely in India. The quantities were large: for instance, to meet the requirements of a year, 20 million yards of khaki drill, 3½ million yards of khaki drill shirting, and 17½ million yards of khaki puggarree cloth had to be provided. Six large modern mills were wholly occupied in making materials for tents, and even

the khaki dyes used were now obtained, to an increasing extent, from Indian resources. That had given a tremendous fillip to the industry, and it was to be hoped that the ground gained would not be lost when peace came. So far he had confined his remarks to the cotton industry, but he thought there was a wider lesson to be learned from the paper, for in many respects what was true of cotton could be applied to other branches of industry where India possessed natural advantages. In his recent visit to India he was greatly impressed with the demands that met him everywhere, that more should be done to encourage the manufacture in India of goods the raw materials of which were produced in India. The history of the cotton trade showed that that could be done. The war had given India many opportunities of developing its own industrial capacities. The Western nations had had to restrict the man-power that they could devote to production, owing to the need for men on sterner tasks. India, at the same time, had had to develop its own efforts in order to supply the forces in the field in Mesopotamia, East Africa, and elsewhere with equipment that could hitherto be obtained from Europe. The necessity for doing this led to the creation of the Munitions Board in India, and from what he saw of their work he was satisfied that a most important step had been taken towards fostering in India the growth of industries which she had hitherto neglected. India was most favourably placed by Nature for the growth of these industries. She produced raw materials on a vast scale; she had abundant supplies of labour; she had, too, a continually-increasing number of young men, well educated and competent to undertake the direction of industrial enterprise. The war had shown the importance of increasing by all available means the self-sufficiency of the Empire—not only of the Empire, but even its separate constituents, for conditions might arise which rendered communications difficult and impeded the free exchange of goods. Even if complete self-sufficiency was not obtainable in any particular case, there was good ground for thinking that India, whose industrial development was still backward, could, under suitable guidance, develop her powers of supplying her own needs to a very large extent. But it was not only from a national or Imperial point of view that he looked forward to the growth of industrial enterprise in India. No one who went to that country could fail to be struck by its enormous wealth of mineral resources and the vast potentialities of its forests and its agriculture and water-pressure. As communications developed there was no reason why it should not have a great industrial future. Anyone who travelled through India could not help being struck by the prevailing low standard of living among the mass of the people, to be seen partly in their appearance and partly in the character of their homes. Nothing had been more strikingly associated with the growth of industrial enterprise in the West than the advancement it brought in the material conditions in which the workers lived. The organisation of labour in modern industry helped to give the worker a status which, as had been seen at home, was not so easily attainable in agriculture. But when it was once recognised that labour had the right to decent conditions of living, to a fair amount of leisure, and to a wage adequate for the discharge of a man's responsibilities, a victory had been won from which the country derived continually increasing benefit. In India wages were low—appallingly low—so low, that a small rise in prices of food or cotton might threaten to create agrarian disturbances. It could not be right that so many should have such a precarious livelihood. If new industries could only be introduced, the status of the worker in India would be improved, and that in its turn would react on the position of the peasant. The door would thus be opened to new opportunities of life and ampler means of happiness than could be obtained under existing conditions.

Sir Charles H. Armstrong said the author was a keen controversialist and a leading citizen of Bombay. His life had been spent in the Bombay cotton-mill industry; but he had, nevertheless, found time to take a leading part in local and Imperial affairs, and was now an active and prominent member of the Imperial Legislative Council, an honour he had long deserved. He had been, the speaker thought, a little hard on Lancashire. In connection with recent legislation, it must not be forgotten, in fairness to Lancashire, that the increase of duty on cotton piece-goods from $3\frac{1}{2}$ to $7\frac{1}{2}$ per cent. was rather sprung upon manufacturers and merchants, and, as a percentage figure of the competitive trade, which was used as a strong argument in the controversy, was undoubtedly underestimated, it appeared at the time as if the matter had not been thoroughly investigated, and as if the interests of consumers had not been fully considered. He did not agree with the author that Indian-made cloth did not compete with goods from Lancashire. He admitted that the qualities were not identical, but in many respects they were nowadays very similar; and when there was an appreciable difference in price in favour of Indian-made goods, the tendency was for poor consumers and those of moderate means to buy Indian cloth in preference to goods from Lancashire. Before the war, Bombay had an advantage of from 5 to 6 per cent., and owing to recent legislation, apart altogether from the very heavy increased charges for working on this side and for freight and insurance, that advantage had increased to 10 per cent., and he could not help thinking that some part of the heavy decline referred to by the author might have been brought about by that increased difference in values. There was no special reason why Lancashire should be jealous of Bombay, nor could he see any reason why Bombay should be jealous of Lancashire; but in connection with recent legislation, and in view

also of the greatly increased cost due to the war—an increase which must to some extent continue for many years—Lancashire had made up its mind that to a very large extent it had lost a valuable bulk trade in India, and that undoubtedly in normal times would be a serious matter. In the past Lancashire had often had difficulties to contend with and had generally managed to surmount them, and he felt pretty certain that in the particular case under discussion English manufacturers would not suffer materially in the long run, for in all probability they would turn on to goods of a more expensive, and therefore of a more paying character, for which, as India increased in wealth, there would be a large and increasing demand. He thought there was ample room for both Bombay and Lancashire millowners, and the people in Bombay need not be prejudiced against their fellow-workers in this country. With reference to the author's statement that the questions of housing and primary education should be dealt with by the Government and not by the Bombay millowners, he thought that, considering the difficult conditions prevailing in Bombay, it was the duty of the Bombay millowners to provide sanitary housing for their workpeople, and it would be greatly to the advantage of both if they did so. He did not understand exactly what the author meant by saying that the Bombay Government had in recent years brought pressure to bear on millowners to provide this very necessary accommodation; but it was true that for eight or ten years the Bombay Government had been anxious that sanitary accommodation should be provided for the mill-hands in Bombay, and, with the object of inducing millowners to build sanitary quarters, the Government, through the Bombay Improvement Trust, had offered terms in connection with the acquisition of land and the erection of buildings which would certainly not involve the mills in any loss, and would, in fact, bring in a moderate return on the capital outlay. When he left India, four years ago, only two or three millowners had taken advantage of the opportunity offered, and he very much regretted that so little had been done in that connection, for, as the Bombay mills were very prosperous, they could easily undertake the work if they only had the mind to do so, and the author admitted that they did not deny a moral obligation. With regard to primary education, he thought that if the mill-hands of Bombay had more education it would be better not only for the hands themselves, but also for their employers. Lancashire recognised that it would have to face in the future the Japanese competition to which the author had referred; but he thought that the Bombay millowners also had reason to fear that competition, as seemed evident from the author's remarks on the subject. He did not approve, however, of the author's suggested remedy, namely, an export duty on the raw material with the object of hampering foreign trade. Japan was the largest foreign buyer of Indian cotton, and if that trade was checked land would undoubtedly have to be turned off cotton to a considerable extent. The cotton crop of India was a large and very valuable one; it was easily grown, and in recent years had fetched very high prices. It would be an agricultural and financial disaster if anything happened in India to bring down the price of cotton materially. He believed the argument was that consumers of Indian cloth would benefit by the lower prices at which goods would be sold, but he was not at all convinced that that would be the result. Many papers had been read before the Royal Society of Arts with the object of stimulating the growth of cotton in India, and the question had recently been under investigation by an influential committee. He was strongly in favour of a largely increased output of Indian cotton, and believed that that was possible. He agreed with the author in hoping that if the committee made practical recommendations the Government would take them up at once. The export of cotton brought immense wealth into the country, and India was helped thereby in the path of industrial development. The author apparently suggested that the management of all the Indian railways should be taken over by the State, but he thought there was some mistake about that, because only the other day he had read a summary of a speech made by Sir Dinshaw in the Imperial Legislative Council in which he strongly advocated that company management should be continued. The grievance expressed in the paper was that Indian industries were placed at a disadvantage by company-managed railways, but he did not think that was really so when everything was taken into consideration and when it was remembered that the same tariff of rates was applicable to both State and company-managed lines. Instances here and there could undoubtedly be brought forward in support of the author's contention, but in fixing railway rates a great many factors had to be taken into consideration. He could not deal on the present occasion with the question of sliding scales and telescopic rates, but the fact remained that, owing to the considerations to which he had referred, certain centres from which there was a large trade inwards and outwards naturally obtained a preference. Indian railways were only worked at a small profit, and the fixing of rates was a matter that had to be carefully considered and all circumstances had to be taken into consideration. He felt sure that those who managed the railways had the interests of India very fully at heart and that a representation on the subject would always be sympathetically considered. He was confident also that in years to come Indian industries would be given every opportunity of development. He felt that the abolition of company management would be a retrograde step, and, so far as he could gather, well-informed Indian opinion, apart from the politicians, was overwhelmingly in favour of its continuance. He hoped that as time went on Indian industries would develop, but questions affecting them must be regarded from the broadest possible standpoint,

with due regard to the welfare of producers as well as consumers and of the country generally. He felt sure there was a very bright future in store for India, and hoped that after the war she would take full advantage of her opportunities.

Sir William Barton, M.P., said that Lancashire, India and the world had the same interest in the matter under discussion, namely, that the largest possible amount of cotton should be grown. Whether it suited Lancashire or not, any grade of cotton supplied some portion of the world's needs and left for Lancashire more of the kind of cotton that it needed. It was becoming more and more evident that sufficient cotton was not at present grown in the world for the world's needs. India had not produced in the past grades of cotton suitable for Lancashire trade, and personally he was sceptical whether it ever would. The climatic and soil conditions of India were such that it was only naturally capable of producing short-staple cotton, and if it could increase its growth of that article it would be making a serious and valuable contribution to the cotton trade of the world. It would thereby relieve for Lancashire the kind of cotton which India must buy if it did not itself produce the lower grade article. When passing from the growth of cotton to the finished article, they entered into the region of controversy, and he did not think that some of the charges which had been made against Lancashire in that respect were justified. The paper would lead an unsuspecting person to think that Lancashire had been moving Parliament for some preferential treatment for its trade. On the contrary, Lancashire had always moved Parliament for the abolition of all preference to all trades. Lancashire believed that the consumers' interest was the preponderating one, and, so long as India had not Home Rule and was not responsible for its own fiscal arrangements, Lancashire said, in the name of the consumers of India, that they desired they should have the same treatment under the law as the consumers of Great Britain. It had been hinted in the paper that the motives of Lancashire were somewhat mixed, but were not also some of the motives set out in the paper very mixed? He claimed for Lancashire that what they had all along asked the Government to do for India was precisely the same thing that they had asked the Government to do for themselves. The Secretary of State was sympathetic to the views he (Sir W. Barton) had held for many years with regard to the government of India. He was a democrat, believing in self-government not only for the nearer portions of the Empire but for every portion of the Empire. He asked Indians who were present not to go away with the idea that there was any inherent conflict of interest between those engaged in the cotton industry in England and those interested in the trade in India. In the long run what was good for Indian people would be good for English people. It might be in the future that Lancashire would lose its trade in certain coarser articles, but cotton was a very big commodity, and whilst there was a low-grade cotton in India Lancashire would be able more largely to use the very high-grade cotton from Egypt. He had no doubt Lancashire would emerge triumphantly from the period of great difficulty which undoubtedly lay before it. He thought the suggestion contained in the paper of an export duty on cotton going to Japan was a most dangerous one. It was unthinkable that a discrimination should be made only against Japan, which was one of our Allies, as against all other nations. An export duty on any raw material was the most dangerous expedient upon which any government could embark.

Mr. Alfred Dickinson, M.Inst.C.E., M.I.E.E., M.I.Mech.E., Consulting Engineer, Tata Hydro Electric Power Supply Company, said it had been pointed out that better cotton was grown in Egypt than in India; this was because the land was enriched by the natural fertiliser brought down by the River Nile. In India there was an absence of natural fertilisers, and, therefore, the land was poor, but it could be enriched by means of manufactured fertilisers and made to produce long-staple cotton. Fertilisers could be made cheaply by water-power. There is plenty of water in various parts of India which could be developed for that purpose. The Government ought to give every facility to reliable firms willing to undertake the manufacture of fertilisers by water-power, or themselves take immediate action with the object of securing cheap fertilisers.

Mr. Bhupendranath Basu, Member of the Council of India, in moving a vote of thanks to Sir Dinshaw Wacha for his paper and to Sir Charles Armstrong for reading it, said that people in Bengal who were not millowners had watched the growth of prices of cotton goods in India, and the consequent hardship such growth had entailed upon the consumer. They had also watched the enormous profits which cotton-mill owners in India had made, and could not understand why there should be any objection on their part to providing suitable houses for working-people and facilities for the instruction of their children. They knew something of the conditions of the life of the poor in Bombay and the houses in which they lived and of the ravages that plague made amongst them, and under those circumstances they could not reconcile the prosperity of the cotton-mill owners with their unwillingness to contribute to the happiness and comfort of the operatives they employed. At present there was no organisation of labour in India, and probably would not be for many years; and he would like to know what increase of wages had been granted to the cotton operatives, to whom Sir Dinshaw was unwilling to grant the boon of providing sanitary dwellings, in view of the fact that they were unorganised? The owners of jute-mills in Calcutta had also made phenomenal profits during the past year, and what had they done for their operatives? How much of the

profits had gone to the owners and how little to the workmen, whose labour had enabled them to earn such large profits? For many years to come, owing to want of education amongst the poorer working-people, labour organisations and unions such as were seen in England and other European countries were not likely to grow in India, and therefore he did not see why it should not be the function of the State to come to the assistance of people who were not able to help themselves. He would not go into the vexed question of the relative merits of the dispute between Lancashire and Bombay. Indians, however, felt they had a grievance against Lancashire, their bigger brother in the industry, in its treatment of India in that respect. Personally, he did not associate himself with the imposition of an export duty on raw materials, it being a very dangerous proposition. It would ultimately mean loss to the cultivator and shrinkage of the area under cultivation. The cultivator ought to have open to him the whole of the markets of the world. Owing to war conditions jute did not have a free market; it could only be used by the millowners in Dundee and Bengal, with the result that they were able to organise and force down the price to such an extent that the growers of jute at one time seriously thought of burning their crops rather than cutting and selling them on the terms offered.

SIR FREDERICK A. ROBERTSON, K.B.E., LL.D., in seconding the motion, endorsed the Secretary of State's remarks in regard to the enormous value to India of an increase in her industries and also of finding proper channels into which the clever, educated young men of India could direct their attention in lieu of the only professions they at present sought to enter, *i.e.*, Government service or a "learned profession."

SIR HAMILTON FREER-SMITH, C.S.I. (President of the Indian Factory Labour Committee, 1906–7), in supporting the motion, said he thought that more should have been said about the welfare of the 240,000 workers in the cotton industry. The dwellings of the workers that he saw in Bombay were a disgrace to humanity and civilisation, a standing menace not only to the health of the workers, but also to the whole community. It was largely due to the petty discussion that had arisen as to who should provide proper accommodation. The time had come when the housing question should be seriously taken up, and also other questions connected with the industry, such, for instance, as slack administration of the Factory Acts, enabling half-timers to work whole time by working in two mills on the same day; excess of humidity in weaving sheds; excess of dust in certain works, and dangerous machinery.

The motion was unanimously adopted and acknowledged by Sir Charles Armstrong on behalf of Sir Dinshaw Wacha and himself.

SIR WILLIAM DUKE, G.C.I.E., K.C.S.I. (Chairman of the Indian Section Committee), in thanking the Secretary of State for presiding, said the Society knew it could always count upon Mr. Montagu's active interest in connection with any subject which was of real importance to India. The subject-matter of the paper was regarded as of somewhat special importance, while the occasion of the meeting was also of peculiar importance, so far as the Society was concerned, from a sentimental point of view, because the present meeting completed the fiftieth annual session of the Indian Section of the Royal Society of Arts. The Society was, therefore, all the more grateful to the Secretary of State for having honoured it by his presence on such an occasion.

The resolution having been carried by acclamation, the CHAIRMAN assured the Society that it had been a very great pleasure to him to be present, and he desired heartily to congratulate the Indian Section upon attaining its jubilee.

MR. D. T. CHADWICK, I.C.S. (Indian Trade Commissioner), who would have spoken at the meeting if time had permitted, writes:—Sir Dinshaw Wacha, in his most excellent summary, touched on most of the problems connected with cotton in India. Others spoke on the attitude of Lancashire and the condition of the Bombay operative, but one point so far was not mentioned, viz., the raw cotton, which is really the base of the industry. It is clear that there has been a great increase in the quantity of cotton produced, but I feel that Sir Dinshaw gives a somewhat pessimistic account of the conditions and prospects of this cultivation. It is true that the yield per acre is considerably less than in the United States and Egypt, but the Egyptian crop is primarily an irrigated one, whilst that of India is mainly a rain-fed crop. Even so I should not like it to go forth that 66 lb. is a normal yield per acre in India. The figures quoted are those for the current year, which was notoriously unfavourable to the cotton crop in our largest cotton areas, viz., the Central Provinces, Hyderabad, and Bombay. The average normal yield is from 85 to 90 lb. Sir Dinshaw does not anticipate much improvement in quantity and quality until the financial position of the ryot has been improved, and elementary agricultural education becomes general, but improvements are not waiting upon the realisation of such efforts. Much has been done, and is being done, in the selection and distribution of better seed, in the organisation of selling and marketing, in the testing of new varieties, and in the selling and distribution of new agricultural machinery. Thus, in the Central Provinces alone, over 800,000 acres were, in 1916–17, cultivated with a particular type of cotton which had been obtained by selection, and which had given at experimental stations over a period of seven years an average yield of 204 lb. of lint per acre as compared with the normal yield of a little over 100. This has meant an increased

profit of over 120 lakhs a year to the farmers in that Province alone. In the Punjab over 200,000 acres have been sown with a long-staple variety of heavier yield, more profitable than previous kinds in both quality and quantity. In South Madras a very similar result has been obtained on a very similar scale, whereby ryots are getting a premium of 16 rupees per 500 lb. on account of the superior quality and purity of the cotton. Moreover, in the south, Cambodia—a stamp of cotton when delivered pure well suited for Lancashire—has been introduced and is being grown extensively. There is as good Cambodia available as was ever grown, and most of the best is procured by local mills. These are merely cited as far-flung illustrations of work in progress everywhere.

Thus, whilst I am in full agreement with Sir Dinshaw that much work remains to be done—for the total area under cotton in India runs from twenty to twenty-five million acres—yet results that have recently been obtained hold out promise that with steady work, and above all with surety of a good market, much could be effected both in increasing the yield and in the improvement of quality of Indian cotton, and from such advance Indian mills should be the first to reap the benefit. India is vastly nearer such achievements than she was fifty years ago. The improvements effected are not restricted purely to seed, but also extend to the use of new implements and better methods of cultivation. Thus again, purely for illustration, the Bombay Agricultural Department last year sold direct to cultivators machinery worth 92,000 rupees. It is, therefore, natural that the recommendations of the Indian Cotton Committee are being awaited with much interest, in the hope that they will give direction to future effort and advice as to the lines which can most profitably be followed.

One of the main difficulties which has so far faced the agricultural reformer is not the impossibility of growing a better article, but the difficulty of ensuring that the full reward of such improvement reaches the cultivator. Without the stimulus of price and the surety of his market it is unreasonable to expect any farmer to venture more capital on his cultivation, or to risk new methods except, perhaps, under the fear of absolute extinction. It has been truly said that high manuring is no remedy for low prices. Thus, when at last these changes are beginning to take effect, and ryots in many parts are beginning to get some of the extra profits due to them for better cultivation and greater care, it is disturbing to hear that certain thinkers—I do not quite gather that Sir Dinshaw endorses this contention—contemplate a restriction of the ryots' market, even resulting in a decrease of the area cultivated and of total production which would, of course, result from a narrow market and a low price. Nothing would be more likely to throw back the small improvements already obtained, and to check further progress, as the uncertainty which would then take the place of that confidence which ryots have now learnt to repose in cotton. It is easy to say that the place of cotton could be taken by some other marketable crop, but in much of the land on which cotton is cultivated cotton is the main money crop to the farmer, and the land, climate and agricultural conditions do not often permit of others being substituted. Such an economic loss to the cultivators of one of our most important staples would have a far wider and more serious effect than the assessment which is put forward as one of the chief causes of the ryots' penury, of which, by the way, recent examinations of registered agricultural leases in ryotwari parts of Madras showed the assessment was about one-sixth of what the landlord takes as rent. I refer to lands temporarily settled and not held under permanent settlements. Agriculturists in India in their work towards the improvement of local crops have derived, generally speaking, most valuable help and advice from the local industries where such are established in India. This has notably been the case in cotton, and had there been no local mills to help with advice, make tests of samples and give enhanced prices for better grades, there could not have been so much agricultural progress to report as at present there is.

As others dealt with trade matters I have confined myself purely to agriculture, and as an agriculturist can say that a better balance between industry and agriculture in India will be all to the benefit of Indian agriculturists.

Mr. E. C. de Segundo, Assoc.M.Inst.C.E., writes:—One of the most important of the many important results brought about by this terrible world-conflict is the spirit which has been awakened throughout the length and breadth of the Empire, and is operating to consolidate the Empire in a degree exceeding, I venture to think, the most sanguine dreams of the most ardent Imperialists in pre-war days. The valuable and interesting paper of Sir Dinshaw E. Wacha deals with one factor in this process of consolidation, namely, the relative positions of India as a cotton-growing country, and Lancashire as a great market for raw cotton. For reasons which will, no doubt, be well known to many readers, it may be said, without fear of contradiction, that India offers the best prospect of relieving the anomalous position of Lancashire in regard to its supplies of raw cotton, and it is important to note that within the last few years the cultivation of the American variety of cotton in India has progressed in a very satisfactory manner, the production having now reached (during 1917) the equivalent of 400,000 bales of 500 lb., a quantity which, however, is but a small proportion of that which Lancashire usually draws annually from the United States.

In Lancashire, Indian cotton has a bad name, and no doubt spinners have had ample justification for the prejudice they have formed. It must be remembered, however, that it is only within recent years that any serious attention has been given to the science of cotton cultivation, and that spinners themselves are unable to specify the physical characteristics of the cotton they require. The

painstaking research work on cotton cultivation carried out in Egypt by Dr. Lawrence Balls—which, unhappily, was interrupted in 1913, and is not, apparently, to be resumed—gave indication of most valuable results in the direction of bridging the gap between grower and spinner. The expert opinions expressed by such authorities as Mr. D. T. Chadwick, Professor John A. Todd, Dr. Lawrence Balls, and others, leave no doubt as to the practicability of a vast improvement in the methods of cultivation of cotton in India, and in the conditions under which it is brought to market, which would result in a material improvement in the length of staple, the quality of cotton, and the yield per acre.

Sir Dinshaw has touched upon the future of India as an integral part of the Empire, a question which cannot fail gravely to preoccupy the minds of all interested in the welfare of the Empire as a whole. The India of to-day is not what it was when it first came under British rule. We could not think much of the efficiency of British rule if it were. Many instances can now be cited of commercial and industrial development in India, due to the enterprise and great business ability of Indian firms. The evolution of India has reached a stage at which there is danger on the one hand of the parent country failing to realise that the child country is growing up, and, on the other, that the child country, chafing under the restrictive effect of parental authority, may be led prematurely to endeavour to free itself from its leading-strings, and thus, in its inexperience, get rid of the ills it knows only to fly to others it knows not of. We must be under no illusion that this war is going to end war, and the safety of the British Empire, with which the safety of India is indissolubly bound up, demands that the component parts of the Empire be so welded together as to become a self-supporting whole under conditions admitting of the abundance of one part supplying the want of another, to the end that "there may be an equality," as was advised by St. Paul, on general principles, some nineteen hundred years ago. No sane person can to-day fail to discern the meaning of the "handwriting on the wall," and to realise that the storm centre is moving eastwards. It will be the part of wisdom for India to see to it that in concentrating her attention upon internal development and economic position, she is not merely adding to her value as a prize for some nation whose natural resources are already developed up to the hilt, and who is seeking, and must find, fresh fields and pastures new for her surplus population and for the exercise of her industrial activities.

OBITUARY.

Edward Adolphus Victor Abraham.—Mr. Edward A. V. Abraham, who had been a Fellow of the Royal Society of Arts since 1912, died at his residence in Georgetown, British Guiana, on June 4th.

Mr. Abraham was born at Georgetown in 1852, and educated at Queen's College. In 1882 he was created a Notary Public, and five years later was admitted by the Supreme Court as a solicitor. In addition to his extensive legal practice, he undertook a great deal of public work. He was Mayor of Georgetown for the years 1903–5; he served on various commissions, on the Tuberculosis Executive, and the Board of Agriculture, and he was more than once Financial Representative. Besides this, he was a sportsman of the most catholic taste, and took a deep interest in shooting, rowing, cycling, racing, cricket, gymnastics: at one time he even organised a meeting for goat races.

Henry Charles Stephens.—By the death of Mr. Henry Charles Stephens the Society loses a Fellow whose name has figured in its books since 1867. He was born in 1841, and educated at University College, London. He became the senior partner in the firm of ink manufacturers which bears his name, and he was also well known as an agriculturist and breeder of pedigree stock. He represented the Hornsey Division as a Unionist from 1887–1900.

GENERAL NOTES.

Industrial Establishments in India.—Figures recently published by the Department of Statistics in India show that in the year 1915 there were in that country 4,053 industrial establishments, employing in the aggregate 1,335,147 persons. Of the total establishments, 171 were owned by Government, local bodies, or State *darbars*; and 3,882 by companies or individuals. For the leading industries—cotton, jute, etc.—the particulars are given separately. Industries employing less than 5,000 persons are included under "others." The industries in the latter category number 649, with nearly 100,000 hands. Cotton-mills and cotton-ginning and pressing factories combined employed upwards of 400,000 persons. The 72 jute mills, 69 of which are in Bengal and the remaining three in Madras, came next with 250,764 operatives. In addition, 26,305 were working in jute presses. Tanneries and leather works, of which there were 41, had 9,339 employees.

Hydro-Electric Projects in Australia.—According to H.M. Trade Commissioner in Melbourne, it has been decided by the Victorian Government that before undertaking the development of the brown coal deposits, to which considerable attention has been devoted, for the supply of electrical energy, an investigation should be made as to the possibility of utilising the water-powers of the State for the same purpose. The Tasmanian Minister of Mines is reported to have stated that he does not anticipate any difficulty in financing the development of water-power on the King River at a cost of £1,000,000. It is estimated that 45,000 h.p. can be developed on this river.

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CONTENTS.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, JULY 26, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

REPORT ON THE "OWEN JONES" PRIZES.

Following the precedent of 1917, the Council this year, with the kind assistance of the Director of the Victoria and Albert Museum, arranged for a competition of students of Schools of Art in accordance with the terms of the Owen Jones Trust. Notices were issued in November last stating that six prizes would be offered under the usual conditions. Each prize consists of a bound copy of Owen Jones's "Leading Principles in Composition of Ornament" and a Bronze Medal. The competition this year was limited to Designs for (1) Chintzes, and other Stamped, Printed, or Stencilled Textile Materials; (2) Wallpapers; and (3) Tiles. The date for the receipt of competing designs was fixed for June 29th, 1918, and arrangements were made for their inspection at the Victoria and Albert Museum.

The following judges were appointed by the Council to consider the designs submitted: Mr. Alan S. Cole, C.B., Professor W. R. Lethaby, Mr. T. C. Moore, Mr. John Slater, F.R.I.B.A., Sir Frank Warner, K.B.E., and Mr. Arthur Wilcock.

Thirty-seven designs or works were sent in from nine Schools of Art by thirty-one students. The judges report that these numbers are small when compared with those of last year, when one hundred and twenty designs or works were sent in from twenty-two Schools of Art by seventy-three students. The falling off of numbers is attributed partly to war conditions, which are even more strenuous than they were a year ago; and partly to the subjects prescribed for the competition, which are perhaps less attractive than those set in 1917.

The general standard of the work is good, although somewhat uneven, some designs showing quite matured, others very elementary ability. The judges are gratified to find that, generally, greater care has been paid to the technical requirements of the process for which the design is intended, as was suggested by them last year. While they would again insist on this technical quality, it must be understood that it alone would not secure an award where the artistic quality is low.

The awards of the judges are as follows:—

PRIZES.

Almenrader, Dorothy M., School of Art, Hornsey, N.
Design for block-printed Wallpaper filling in fourteen colours.

Bulley, Mary A., L.C.C. School of Art, Putney, S.W.
Two Sheets of Designs for Ceiling papers.

Froom, Dorothy M., School of Art, Hornsey, N.
Design for a block-printed Cretonne in ten colours.

Goodale, Winifred, L.C.C. School of Art, Putney, S.W.
Design for repeating Tile—with Tiles (unfired).

Phillips, Margery L., L.C.C. School of Art, Putney, S.W.
Design for Encaustic Tiles for floor covering.

COMMENDED.

Berry, Ivy A., School of Art, Hornsey, N.
Design for block-printed Wallpaper in sixteen colours.

Goodale, Winifred, L.C.C. School of Art, Putney, S.W.
Design for printed Cretonne to be executed in nine colours.

Grierson, Edith, Municipal School of Art, Manchester.
Design for Printed Textile.

Hammond, Bertram, School of Art, Macclesfield.
Design for Printed Cretonne.

Hodgson, Gladys, School of Art, Hornsey, N.
Design for block-printed Taffeta in eight colours.

Kipling, Arthur W., School of Art, Glossop.
Design for printed Cotton fabric in nine colours.

Tippin, Alice Bertha, City School of Art, Hope Street, Liverpool.
Design for Stencilled Tablecloth with Stencil and preliminary drawing.

Arrangements have been made for the exhibition to the public of the competing designs. They will be on view from July 20th to August 31st, from 10 a.m. to 6 p.m. in the Class Room, Department of Textiles (First Floor), Victoria and Albert Museum, South Kensington, S.W.

In announcing the awards the Council desire to add an expression of their thanks to the judges for the trouble they have devoted to the work and for the promptitude with which the awards have been made.

They wish also to state their appreciation of the assistance rendered to the Society by the Director of the Victoria and Albert Museum and his staff.

The conditions and arrangements for the Competition in 1919 will be announced later.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE EFFECT OF THE WAR ON THE ECONOMIC CONDITION OF THE UNITED KINGDOM.

By Edgar Crammond,

Late Secretary of the Liverpool Stock Exchange; Managing Director of B.S.T. Limited.

Lecture I.—Delivered February 18th, 1918.

It is proposed to discuss the effect of the war upon the economic condition of the United Kingdom, and to offer some observations with regard to the real cost of the war, the problem of economic reconstruction, and our trade policy after the war. The scope of the inquiry is very wide, and it is not practicable to deal with every aspect of the question in great detail.

It will not be possible to pass final judgment upon many of the economic problems which the war has created until a considerable time after the conclusion of peace, but if we are to pursue an intelligent and reasoned policy in relation to our post-war economic problems, we cannot afford to wait until, say, ten years after peace. We must form our conclusions now in the light of the facts as we understand them to-day and the experience which we have obtained during the past three years and a half.

The war marks a close of an old economic epoch and the opening of a new era, and in order to attain a full appreciation of the changes which the war has brought about, it is necessary to consider first the economic position of the United Kingdom before July, 1914.

The question will be considered under three main headings, viz.:—

1. The economic condition of the United Kingdom before the war;
2. The economic condition of the United Kingdom after three and a half years of war;
3. The real cost of the war, the problem of economic reconstruction and trade after the war.

The first question to which attention may be directed is that of population. The table given below shows the growth of population in the United Kingdom since 1821, and relative proportions of each division of the United Kingdom.

The increase of population in the United Kingdom in the inter-censal periods since 1881 was as follows:—

1881–1891	8·2 per cent.
1891–1901	9·9 ,,
1901–1911	9·1 ,,

Between 1881–1911 the population of the United Kingdom increased from 34,884,848 to 45,216,665. Between 1880–1910 the population of the German Empire increased from 45,234,061 to 64,925,993, the increases for the three inter-censal periods being:—

1880–1890	9·3 per cent.
1890–1900	14·0 ,,
1900–1910	15·2 ,,

Census of Population.

Census of	Population of United Kingdom.	Population of England and Wales.	Per cent. of U.K.	Population of Ireland.	Per cent. of U.K.	Population of Scotland.	Per cent. of U.K.
1821	20,893,584	12,000,236	57·4	6,801,827	32·6	3,091,521	10·0
1831	24,028,584	14,156,988	57·9	7,767,401	32·3	2,364,386	9·8
1841	26,730,929	15,914,148	59·5	8,196,597	30·7	2,620,184	9·8
1851	27,390,629	17,927,609	65·5	6,574,278	24·0	2,888,742	10·5
1861	28,927,485	20,066,224	69·4	5,798,967	20·0	3,062,294	10·6
1871	31,484,661	22,712,266	72·1	5,412,377	17·2	3,360,018	10·7
1881	34,884,848	25,974,439	74·5	5,174,836	14·8	3,735,573	10·7
1891	37,732,922	29,002,525	76·8	4,704,750	12·5	4,025,647	10·7
1901	41,458,721	32,527,843	78·4	4,458,775	10·8	4,472,103	10·8
1911	45,216,665	36,075,269	79·8	4,381,951	9·7	4,759,445	10·5

In the ten years 1901–1911 the death-rate of the United Kingdom dropped to 15·7 per thousand, compared with 18·2 for the previous inter-censal period. At the census of 1901 the population of the United Kingdom was 41,458,721, and at that in 1911 it was 45,216,665, the increase between 1901 and 1911 being 3,757,944. The number of births recorded in the inter-censal period was 11,614,000; the number of deaths, 6,771,000, the natural increase thus amounting to 4,843,000. The difference between this figure and the actual recorded increase in the population, viz., 1,086,000, was accounted for by migration, which has, of course, exercised a very marked influence upon the growth of population in the United Kingdom. The Board of Trade figures show that during the inter-censal period emigration amounted to 1,350,000, so that there remains a difference of 264,000 between the census results and the actual recorded emigration. This difference was in part due to the fact that there was a war in South Africa during the decade, and consequently a large movement of troops to and from South Africa, and it is estimated that between 160,000 and 200,000 returning troops were not included in the Board of Trade returns because they arrived on troopships. Between 1901–1911, 336,000 people, or 100 per cent. of its natural increase, emigrated from Ireland. Scotland had a natural increase in population of 51,791 in 1910, but the passengers leaving Scottish ports numbered 55,344 in the same year.

It is instructive to note the nationality and the destinations of emigrants. The English provided 63 per cent., the Scottish 20 per cent., the Irish 13 per cent., the Welsh 1 per cent., and the Colonials 3 per cent. of the total of the 397,000 emigrants gross outwards in 1910. In the past twenty years there was a remarkable change in the destinations of emigrants. In the period 1891–1900, 28 per cent. of the emigrants went to the Dominions and 72 per cent. to foreign countries. In 1900, 33 per cent. went to the Dominions and 67 per cent. to foreign countries. In 1910, 68 per cent. went to the Dominions and 32 per cent. to foreign countries. In 1911, 80 per cent. went to the Dominions and 20 per cent. to foreign countries.

The migration of women has been considerably less than that of men, and the average for the whole forty years has been less than 22 per cent. of the total natural increase of the female population. In the forty years from 1871–1911, 590,000 more males than females emigrated from England and Wales alone. This is the main reason for the great excess of females in England and Wales. In 1871 the excess of females over males was 594,000; in 1881, 694,000; in 1891, 896,000; in 1901, 1,070,000; and in 1911 it rose to 1,179,000. It is instructive to note that, on the other hand, there is a notable deficiency of females in some of the Colonies. In Canada in 1911 there were 437,000 fewer females than males; in New Zealand 55,000 less females, and in Australia 171,000 less females than males.

It is necessary now to consider the occupations and the production of the people of the United Kingdom. The census for 1911 showed that there were 35,748,000 persons, occupied and unoccupied, aged ten years and upwards. Of this total, 2,886,000 males and 12,704,000 females were returned as retired or unoccupied, leaving 14,307,000 males and 5,851,000 females occupied. The returns made under the Census of Production Act give a fairly comprehensive view of the production and principal industries of the United Kingdom in the year 1907. They show that the gross value of the output of the 7,250,000 persons who came within the scope of the Act was £1,765,366,000, and the net output, that is the value of the work done, was £712,135,000. It is estimated that if complete returns had been received with regard to all the persons coming within the scope of the Act the net qutput would have been valued at £762,000,000. The results of the Census of Production, so far as they relate to the industries dealt with in the Census of Production Office, are shown in the table, "Census of Production," given on page 568.

One of the most surprising features of the Production Report was the small number of persons engaged in production and the comparative smallness of the output. The question of distribution is evidently one of great importance. Special inquiry should be directed to this matter. We seem to have had too many persons occupied in distribution and too few occupied in production.

It will be observed that, while the Census of Population gave a total of occupied persons amounting to 20,158,000, the Census of Production only covered the activities of about 8½ million persons. The agricultural output was obtained by the Board of Agriculture and Fisheries, and the Department of Agriculture and Technical Instruction for Ireland, which undertook a voluntary census of agriculture for the year ending June 4th, 1908. The following

CENSUS OF PRODUCTION.

GROUP OF TRADES.	GROSS OUTPUT. Selling Value or Value of Work done.			Average Number of Persons Employed (excluding Outworkers).		
	England and Wales.	Scotland.	Ireland.	England and Wales.	Scotland.	Ireland.
	£	£	£			
Mines and Quarries	125,151,000	22,617,000	258,000	829,371	132,096	3,763
Iron and Steel, Engineering and Shipbuilding Trades	307,809,000	61,573,000	5,814,000	1,270,913	230,691	37,811
Metal Trades, other than Iron and Steel	91,493,000	1,790,000	182,000	108,138	5,555	780
Textiles, except "Other Cotton Manufactures"	279,565,000	29,154,000	15,836,000	984,813	141,184	92,355
"Other Cotton Manufactures"*		[9,006,000*]			[34,692*]	
Clothing Trades	94,056,000	8,737,000	5,190,000	638,159	75,899	42,408
Food and Drink Trades	205,177,000	31,064,000	27,335,000	319,502	70,968	35,583
Tobacco Trade*		[23,870,000*]			[37,648*]	
Chemical and Allied Trades (except Explosives and Ammunition)	63,303,000	6,591,000	1,191,000	103,238	9,274	2,586
Explosives and Ammunition*		[3,947,000*]			[12,744*]	
Paper, Printing, Stationery and Allied Trades	50,845,000	8,771,000	1,692,000	268,476	44.440	12,559
Leather and Canvas Trades	22,849,000	2,945,000	226,000	53,473	6,208	1,004
India-rubber Trade*		[8,908,000*]			[24,039*]	
Timber Trades (except "House Furnishings not of Wood")	31,418,000	7,590,000	1,279,000	180,848	34,480	7,706
"House Furnishings not of Wood"*		[6,103,000*]			[16,161*]	
Clay, Stone, Building and Contracting Trades	101,443,000	12,831,000	2,418,000	626,138	80,557	18,545
Miscellaneous Trades	7,615,000	599,000	74,000	42,584	3,940	350
Public Utility Services	67,538,000	6,609,000	2,904,000	280,673	29,395	32,423
Factory Owners—Power only	—	—	—	806	—	—
Total	1,490,749,000	207,840,000	66,777,000	5,808,269	885,403	291,304

* In the case of these trades separate particulars for the several divisions of the United Kingdom are not given in order to avoid possible disclosures of information relating to certain firms. In the total figures for all trades for England and Wales, for Scotland, and for Ireland separately, a distribution of these amounts and numbers has been included.

table sets forth the particulars contained in the reports of those bodies:—

	Agricultural Produce.	Number of Persons employed.
	£	
England and Wales	127,650,000	*1,128,000
Scotland	23,150,000	212,000
Ireland	45,574,000	†984,000
Total	196,374,000	2,324,000

Particulars as to fisheries are as under:—

	Value of Fish landed.	Persons employed. Regularly.	Occasionally.
	£		
England & Wales	8,156,000	36,210	7,464
Scotland	3,221,000	28,951	10,366
Ireland	341,000	8,027	16,405
Total	11,718,000	73,188	34,235

* England and Wales—persons employed, excluding occupiers numbering about 500,000 in Great Britain.

† Ireland—persons employed, including farmers.

There are consequently 2,931,000 persons engaged in agriculture and fishing, and the total output was approximately £208,000,000. In considering this total, it should be observed that it excludes the value of dairy produce and cider consumed by farmers' households in Great Britain, the output of farm, market garden and fruit crops from holdings not exceeding one acre, and certain other produce; but it appears not unreasonable to estimate the value of the total agricultural and garden output and fisheries at about £222,000,000.

The question of the national food supply before the war has been carefully studied by the Food (War Committee) of the Royal Society, and their conclusions are embodied in Command Paper 8421. It was found necessary to convert the total food consumed to a common basis. "For this purpose it was necessary to select some unit of measurement which is common to all foods. Observations have shown that the human being derives his power of work from the oxidation of his food, which in this respect is comparable to the fuel of a steam

TABLE V.

SUMMARY OF FOOD SUPPLY OF UNITED KINGDOM.

Average of five years, 1909 to 1913 inclusive.

	Weight in Metric tons.			Work-producing Power in Millions of calories.		
	Home Grown.	Imported.	Total.	Home Grown.	Imported.	Total.
Cereals	1,010,000	3,855,000	4,865,000	3,705,000	14,007,000	17,712,000
Meat	1,615,000	1,070,000	2,685,000	5,369,000	3,521,000	8,890,000
Poultry and eggs, game and rabbits	170,000	161,000	331,000	235,000	226,000	461,000
Fish	715,500	132,900	848,400	392,000	139,000	531,000
Dairy produce (including lard and margarine)	4,704,000	527,800	5,231,800	4,715,000	3,538,000	8,253,000
Fruit	341,000	930,000	1,271,000	168,000	909,000	1,077,000
Potatoes and other vegetables	4,788,000	694,000	5,482,000	4,054,000	758,000	4,812,000
Sugar (including cocoa and chocolate)	—	1,657,000	1,657,000	—	6,633,000	6,633,000
Cottage and farm produce not included above	—	—	—	2,655,000	—	2,655,000
Totals	—	—	—	21,293,000	29,731,000	51,024,000

engine or motor car. The work-producing power of coal, oil, or petrol is measured in calories, or units of heat. This unit is the most convenient measure for the work-producing power of foods. A full consideration of the dietary requirements of a nation for the most part engaged in active work has convinced the Committee that these requirements cannot be satisfactorily met on a less supply in the foods purchased than 100 grammes protein, 100 grammes fat, 500 grammes carbo-hydrates, equal approximately to between 3,400 calories per man per day—a man being an average workman doing an average day's work. The population of the United Kingdom was taken as 45·2 millions. Generally speaking, a woman or child requires less food than a man. To afford the population of men, women, and children the net units per man as defined above, the total number must be reduced by 23 per cent. The quantities of foodstuffs available during the period 1909–13 were:—

	Protein. Grammes.	Fat. Grammes.	Carbo-hydrates. Grammes.	Calories.
Per head	87	100	440	3,091
Per man	113	130	571	5,009

The supply, therefore, not only met our requirements in the past, but also provided a margin of 600 calories per man, or 15 per cent.

With regard to the question as to the proportion of food that was home grown, the investigations of the Committee referred to showed that out of 51,000,000 calories consumed, 29,700,000 calories, or 58·2 per cent., were imported, and only 21,300,000 calories, or 41·8 per cent., were home grown (see Table V.). This does not quite agree with the returns made under the Census of Production, which indicated that the value of imported foodstuffs was £244·7 millions, and the home grown food production of £205·3 millions; that is, the imports represented 45·2 per cent. of the value of the food consumed, and the home grown proportion was 45·8 per cent.

The interdependence of the United Kingdom on foreign trade is one of the most striking features of the Census of Production Report. The value of the raw materials produced in the United Kingdom was £149·6 millions, of which total coal represented £114·6 millions. The value of the exports of raw materials was £43·5 millions, leaving the home consumption of raw materials produced in the United Kingdom £106·1 millions. The value of the net imports of raw materials was £192·1 millions, so that in 1907 the total consumption of raw materials was £298·2 millions, of which £192·1 millions, or 64·4 per cent., were obtained from abroad and 35·6 per cent. were produced at home. It will be observed, therefore, that we are even more dependent upon foreign supplies of raw materials than we are upon foreign supplies of food.

The returns made under the Census of Production enable us to frame some conclusion as to the amount of the national income and the manner in which it is spent; and after a careful and detailed examination of these returns, together with the figures relating to our foreign

trade contained in the Statistical Abstract, I have prepared the following estimate of the national income and national expenditure for the year 1907:—

FOOD.

(Millions of £)

	Home Production.	Imports.	Exports.	Estimated Home Consumption.
Wheat and Flour	10·6	44·0	0·6	54·0
Potatoes	11·7	—	—	11·7
Vegetables	11·6	5·2	0·4	16·4
Meat	83·5	51·9	1·7	133·7
Fish	11·7	2·9	1·5	13·1
Milk	28·4	—	—	28·4
Butter and Margarine	9·6	25·4	0·4	34·6
Cheese	1·4	6·9	0·2	8·1
Eggs and Poultry	10·3	7·1	—	17·4
Lard	—	4·9	0·1	4·8
Fruit (including Dried Fruit imported and Spices)	5·6	15·1	1·2	19·5
Sugar (deduct 10 per cent. for quantity used in brewing and distilling, and add allowance for refining at home)	—	20·7	0·7	20·0
Tea (plus one-seventh for landing and warehousing)	—	10·9	2·1	8·8
Coffee	—	2·4	1·3	1·1
Cocoa (plus one-seventh for landing and warehousing)	—	3·0	0·5	2·5 0·5
				374·6

DRINK AND TOBACCO.

	Home Production.	Imports.	Exports.	Estimated Home Consumption.
Beer	67·2	—	1·9	65·3
Spirits	8·8	—	3·1	5·7
Brandy and Liqueurs	—	1·8	0·2	1·6
Wine (plus one-eighth for landing and warehousing)	—	4·4	0·5	3·9
Tobacco	23·9	4·2	1·4	26·7
Aerated Waters	6·0	—	0·6	5·4
				108·6
Total Food, Drink and Tobacco				483·2

DRESS.

	Home Production.	Imports.	Exports.	Estimated Home Consumption.
Cotton Manufactures	174·6	9·8	113·5	70·9
Woollen Manufactures	75·9	10·8	34·8	51·9
Linen	18·6	1·6	7·0	13·2
Silk	5·2	13·4	4·4	14·2
Leather (including Boots, Shoes and Gloves)	41·4	12·7	8·2	45·9
Diamonds	—	8·8	0·3	8·5
Lace	—	1·6	—	1·6
Feathers	—	2·5	1·2	1·3
Miscellaneous (including Perfumery)	—	—	—	3·6
Net output of clothing, handkerchief and millinery trades	64·7	—	—	64·7
Laundry and cleaning	9·4	—	—	9·4
				285·2
Deduct estimated proportion of Home Consumption of Cotton, Woollen, Linen and Leather Manufactures used for other purposes than Dress				37·0
				248·2

HOUSE.

	Home Production.	Imports.	Exports.	Estimated Home Consumption.
House Rent (from House Duty Returns)	—	—	—	150·0
Furniture and Miscellaneous	18·1	12·3	12·0	18·4
China, Glass and Earthenware	7·6	1·0	4·2	4·4
Coal (34,000,000 tons at £1 per ton)	—	—	—	34·0
Gas—				
Companies	20·8			
Public Authorities	10·8	Less estimated proportion used in manufacturing, etc., industries		28·5
Electric Light—				
Companies	3·2			
Public Authorities	5·7			
Water—				
Companies	2·2			
Public Authorities	8·5	do.		10·7
				246·0

NATIONAL SERVICES, 1907-8.

Army and Navy	58·0
Post Office	18·0
Civil List and Civil Administration (less education)	19·0
Local Government Services (less education, gas, water and other items)	89·0
Total	184·0

MISCELLANEOUS.

Education (including Parliamentary grants and local rates)	40·0
Literature	23·0
Newspapers	14·0
Church (including 14·0 for revenues of Church of England, with estimates for Scotland and Ireland, and for dissent)	25·0
Locomotion—	
Tramways— Companies 4·5, Public Authorities 9·3	13·8
Half receipts from Railway passengers	25·5
Motoring	20·0
Theatres and Amusements	25·0
Total	186·3

The cost of distribution is, of course, a very formidable item in the national expenditure, and with regard to this matter the final report states :—

"The accounts of the English Co-operative Wholesale Society show that the expenses of their wholesale business range from 1½ per cent. on purchases in the case of grocery (where the transactions are on a very large scale) to 5 or 8 per cent. in the case of other goods. The Wholesale Society does not work for a commercial profit. Examination of the accounts of a considerable number of large distributive co-operative societies, working in competitive districts, shows that profits and expenses together run between 20 and 35 per cent. of the cost of purchases, from 8 to 12 per cent. representing expenses. Inquiries made by the Census of Production Office regarding ordinary retail trade show that when allowance is made for certain cases where the sum required to cover retailers' expenses and profits may fall as low as 10 per cent. of the cost of the goods to the retailer, and for other cases where that sum may rise above 50 or even 100 per cent. of the cost, an addition of from 25 to 40 per cent. to the cost of goods to the retailer will, for the great bulk of trade, express the range within which the expenses and profits of retailers lie."

The following is a summary of the national expenditure for the year 1907, on the basis of the figures quoted above :—

	Amount. (Million £)	Percentage of total income.
Food, Drink and Tobacco	483·2	22·4
Dress	248·2	11·5
House	246·0	11·4
National Services	184·0	8·5
Miscellaneous	186·3	8·6
Professional and Domestic Services not comprised in above items	100·0	4·6
Cost of Distribution	200·0	9·3
	1,647·7	
Depreciation and Maintenance of Capital	180·0	8·3
New Investments at home	150·0	7·4
New Investments abroad	176·0	8·0
	2,153·7	100·0

Thus, before the war, food, clothes, rent, the cost of distribution and miscellaneous services absorbed about 67·8 per cent. of the national income. National Services only called for 8·5 per cent.; depreciation, 8·3 per cent.; while 15·4 per cent. was saved—the latter item being fairly evenly divided between new investments at home and new investments abroad.

The income tax returns confirm the estimate of the national income arrived at on the basis of the Census of Production returns. The rule of thumb method of estimating the aggregate income is to double the gross assessment to income tax. For the year to March, 1909, the gross income reviewed by the several bodies of Income Tax Commissioners amounted to £1,009,935,926; and, applying the method indicated above, we arrive at an aggregate income of about £2,020,000,000.

Shipping, including its allied trades, constitutes our premier industry; and I have prepared the following table to show the total

number of persons engaged, and the aggregate capital employed:—*

	Approximate number of persons employed.	Approximate amount of capital employed. £
Shipping	300,000†	600,000,000
Shipbuilding	210,000	150,000,000
Port and Harbour Authorities	60,000	140,000,000
Miscellaneous (including dock labourers, warehousemen, shipping clerks, underwriters, etc.)	260,000	100,000,000
	830,000	£990,000,000

If we include the persons employed in fishing and the peace establishment of the Royal Navy, it will be found that the total number of persons directly employed in connection with our shipping exceeds 1,000,000.

It is now necessary to consider the growth of our foreign trade. During the ten years which preceded the outbreak of war, there was a remarkable development of the foreign trade of the United Kingdom. The nature and extent of the expansion in shown in the following table:—

Imports.	(Million £) 1904.	1913.	Increase per cent.
Food	219·7	274·3	24·8
Raw Materials (other than Coal)	143·0	217·8	52·3
Manufactured Articles	115·9	164·1	41·6
Re-exports (Transit Trade)	70·3	109·5	55·8
Miscellaneous	2·1	3·0	42·0
	551·0	768·7	39·5

Exports.	(Million £) 1904.	1913.	Increase per cent.
Food	16·7	32·6	93·2
Raw Materials (other than Coal)	9·3	16·2	73·4
Manufactured Articles	243·3	411·4	69·0
Coal	26·8	53·6	99·7
Re-exports	70·3	109·6	55·8
Miscellaneous	4·6	11·4	166·0
	371·0	634·8	71·1

In 1904, the value of the imports exceeded the value of the exports by £180 millions, whereas in 1913 the excess of imports was only £133·9 millions. This was due to the fact that the exports increased at a much more rapid rate than the imports. Of course, in 1904 we were beginning to recover from the effects of the South African War, and we had resumed the investment of capital abroad, which had been interrupted during the war. The investment of capital abroad has exercised a very great influence upon the expansion and direction of British trade.

Exports and Investments.—The Board of Trade returns for the past thirty years, together with the data available as to the investment of capital abroad, establish in the clearest manner the absolute dependence of our exports of commodities upon the amount of capital lent to our foreign and colonial debtors. Between 1880 and 1890, we lent money on a liberal scale to the United States, Argentina, and Australasia. In fact, we lent too freely, and without discrimination. During the decade, the total amount invested abroad was about £600,000,000, or at the rate of £60,000,000 per annum. Now, in 1880 the exports of United Kingdom produce were valued at £223,000,000; and in 1890, at £263,000,000, thus showing an increase during the eleven years of £40,000,000. In the early nineties our foreign investments began to show heavy losses. These were in part due to the shrinkage in the value of our investments in Brazil and Argentina, owing to the revolutionary troubles in those countries, and to the Baring crisis, which followed in 1890. Then the passing of the Sherman Silver Act in the United States was followed by a commercial and financial crisis, which caused several bank failures; and many of the American railways passed into the hands of receivers. The closing of the Indian Mints, in 1893, depreciated the value of our investments in all silver countries, and the same year witnessed an acute financial crisis in Australia. These unfavourable events, and the heavy losses which they entailed, naturally made a profound impression upon the mind of the British investor, and the total amount invested abroad during the decade 1890–1900 was only £250,000,000, or at the rate of £25,000,000 per annum. The effect of this contraction of credit upon our exports was immediate and unmistakable. Our exports of United Kingdom produce, valued at £263,000,000 in 1890, fell to £216,000,000 in 1894, and by 1899 they had recovered only to £255,000,000, or £8,000,000 less than the total at which they were valued in 1890. It is also instructive to note that during the period when our investments abroad were on a very small scale, there was a huge appreciation in the market value of home securities.

The drastic measures taken by British investors compelled our foreign and colonial debtors to place their finances in a sound position, to live within their income, and to develop their natural resources in the most

* The British Shipping Industry.

† Including 31,000 foreigners and 51,000 Lascars.

economical and efficient manner possible; and by the end of 1899 our foreign investments were beginning to yield a largely increased income. Our imports amounted to £421,000,000 in 1890, when our exports of United Kingdom produce were valued at £263,000,000; whereas, in 1899, when our exports of United Kingdom produce were valued at only £255,000,000, our imports were £485,000,000, and there is no evidence whatever to show that during that time we were selling our investments abroad. Towards the end of the decade the confidence of British investors in foreign investments was, therefore, beginning to revive; and there was a marked tendency to resume the outflow of capital on a considerable scale when the South African War broke out. The losses and expenses caused by this conflict resulted in a partial suspension of the investment of capital abroad for two or three years. But during the war there was a world-wide improvement in trade, due in part to a succession of good crops in the United States, Canada, and Argentina, as well as to the reaction after the universal depression of 1890–1899, with the result that our foreign investments not only became very remunerative, but greatly improved in value. As soon, therefore, as the wastage and cost of the war ceased, British capital was available for investment abroad on a very large scale, and from 1904 onwards it was poured out by this country at an unprecedented rate, with the result that there was a tremendous increase in the value of our exports of manufacture.

Income from Investments Abroad. — The amount of income which the Commissioners of Inland Revenue were able to earmark as derived from colonial and foreign investments in the year ended April 5th, 1914, was £118,113,703, made up of £9,206,703 from Indian Government stocks, loans, and guaranteed railways; £27,766,323 from colonial and foreign Government securities, and £80,640,677 from colonial and foreign securities other than Government. But these items form only part of the total income which accrues to this country in respect of its foreign and colonial investments, for they do not include: (*a*) Concerns (other than railways) situated abroad, but having their seat of direction and management in this country—*e.g.* mines, gasworks, waterworks, tramways, breweries, tea and coffee plantations, nitrate grounds, oilfields, land and financial companies; (*b*) concerns jointly worked abroad and in this country, such as electric telegraph cables and shipping; (*c*) foreign and colonial branches of banks, insurance companies, and mercantile houses in the United Kingdom; (*d*) mortgages of property and other loans and deposits abroad belonging to banks, insurance companies, land, mortgage, and financial companies, etc., in this country; and (*e*) profits of all kinds arising from business done abroad by manufacturers, merchants, and commission agents resident in the United Kingdom. There is ground for the belief that the income derived from the sources which are not earmarked by the Commissioners of Inland Revenue approximates to that of the identified income; but if the unidentified income is assumed to equal only 80 per cent. of the identified income, it amounts to at least £95,000,000. The total income from foreign and colonial investments would thus be well over £200,000,000 per annum, which, capitalised on the basis of twenty years' purchase, represents an aggregate capital sum of £4,000,000,000.

Capital Invested.—Confirmation of this estimate is afforded by a detailed examination of the amount of British capital invested in each of our Overseas Dominions and Possessions, and in each foreign country. The following summary indicates the approximate distribution of our foreign and colonial investments in millions of pounds at the end of 1913, together with the comparative figures for 1896:—

British Dominions, Colonies and Possessions.	1896.	1913.	Increase.
India (including Ceylon)	294	447	153
Australia and New Zealand	323	408	85
Africa	333	401	68
Canada	140	423	283
Other British Possessions	33	91	58
Total	1,123	1,770	647
Foreign Countries.			
United States	315	632	317
Argentina	117	329	212
Brazil	45	135	90
Mexico	27	81	54
Japan	13	74	61
Chile	29	57	28
Egypt	51	75	24
Uruguay	23	40	17
China	26	38	12
Peru	21	32	11
Cuba	5	29	24
European Countries	254	170	84*
Other foreign countries	43	92	49
Total	969	1,784	815
Grand total, British Dominions and foreign countries	2,092	3,554	1,462

This aggregate of £3,554,000,000 comprises only the capital invested in colonial or foreign

* Decrease.

loans or in public undertakings or companies, and it does not include any provision for the very large amounts of capital privately invested abroad in the purchase of land, etc., nor the capital employed abroad by the principal British banking, mercantile, and shipping houses. If it be assumed that these private investments are equivalent to 10 per cent. of the public investments—a very moderate estimate—a further sum of £350,000,000 must be added to the total, making the aggregate value of all British investments abroad £4,000,000,000, a total which approximates to that arrived at on the basis of the capitalisation of the estimated income at 5 per cent.

Geographical Distribution.—It will be observed that the total of the investments has been fairly evenly divided between the Overseas Dominions and the rest of the world, and that the British investor has taken good care not to place all his eggs in one basket. The moiety invested in the Empire has been almost equally distributed among the three great Dominions and our greatest Dependency, and although upwards of £600,000,000 of British capital was placed in the United States, the remainder of the moiety invested in foreign countries was very well spread. In the early years our principal investments were made in Europe, but as the European countries developed and the yield became less remunerative, it was perceived that Canada, Australia, Argentina, Chile, and other distant countries offered a more profitable field. France, and to a lesser degree Germany, invested their surplus accumulations of capital largely in Russia, Turkey, Austria, the Balkan States, and other parts of Europe. Great Britain, on the other hand, pursued a bolder policy, one which was largely influenced by her shipping, and she has no reason just now to regret having invested her savings in the development of countries which are in the main remote from Europe.

The great bulk of the capital invested abroad by Great Britain has been applied to the construction of railways, irrigation works, waterworks, and harbours, or to the development of mines, nitrate fields, tea, coffee and rubber plantations, oilfields, etc.—in short, to every conceivable form of enterprise calculated to increase the world's supplies of food and raw materials. This increase of productiveness has not been conducted on selfish lines. The additional supplies of food and raw materials have been made accessible to the whole world; and it is difficult to believe that the industrial development of Germany during the past twenty years would have been possible had it not been for the enterprise and ability of British investors. The value of British investments abroad increased during the seventeen years, 1896–1913, by the enormous sum of £1,462,000,000, or at the average rate of £86,000,000 per annum. The decrease of £84,000,000 in the value of our investments in Europe is noteworthy.

We are now in a position to examine the manner in which our trade balance was adjusted before the war. I believe it is not yet generally appreciated that the value of our exports as shown in the Board of Trade returns is "f.o.b.," that is, free on board, and the value of the imports is "c.i.f.," that is, cost, insurance and freight. As we carry, insure and finance three-fourths of our own trade, and at least one-half of the sea-borne commerce of the world, it is obvious that the real position of our trade balance is very much better than would appear by merely considering the values of the imports and exports. The following estimate gives the approximate figures for 1912, so far as I have been able to calculate them.*

UNITED KINGDOM, YEAR 1912.

Credits.

	£
Exports of domestic produce, etc.	487,434,000
Re-exports	111,838,000
Exports of bullion and specie	64,871,000
Invisible Exports—	
Interest on investments abroad	185,000,000
Proportion of gross earnings of British mercantile marine brought home, say	100,000,000
Gross earnings of British banking, mercantile, commission and insurance houses carrying on trade abroad	55,000,000
Total	£1,004,143,000

Debits.

	£
Imports—	
Commodities	444,897,000
Bullion and specie	76,311,000
Invisible Imports—	
Amount of capital invested abroad	185,000,000
Interest payable on foreign and colonial holdings of British securities, and earnings of foreign and colonial banks, insurance companies, etc., carrying on British business within the U.K.	20,000,000
Total	£1,026,208,000

It is out of the question to submit a statement which will show an exact balance, because there are so many items which enter into the

* "Economic Relations of the British and German Empires," *Journal of the Royal Statistical Society*, June, 1914.

adjustment of the trade balance for which no reliable data are available. The above table does not include the value of the fish landed at British ports during the year 1912, which amounted to £13,234,000, nor does it include the imports and exports of precious stones (the average value of the net imports cannot be less than £4,000,000 per annum). Again, it is impossible to frame estimates of the amount annually expended abroad by British tourists or the earnings of British subjects abroad which are annually remitted home to this country. In this connection it is interesting to note that the pensions payable in England by the Indian Government alone exceed £2,000,000 per annum. It is equally difficult to frame an estimate of the amount annually expended in the United Kingdom by foreign tourists, or the earnings of foreigners resident in this country which are annually remitted abroad. On the whole, it may be assumed that these two groups of income and expenditure set off each other.

Before the war the national finances were in an eminently sound condition. Almost alone amongst the Great Powers we were steadily reducing the amount of the National Debt. At the end of the South African War it stood at £798,000,000; by the end of 1913 we had got it down to £707,000,000—or say, about 4½ per cent. of the estimated national wealth.

The revenue of the Imperial Government for the year to March 31st, 1914, was £198,000,000 —or, say, about 9 per cent. of the national income—and was derived from the following sources:—

	£
Customs	35,450,000
Excise	39,590,000
Estate Duties	27,359,000
Stamps	9,966,000
House Duty, etc.	3,415,000
Income Tax, etc.	47,249,000
	£163,029,000
Non-Tax Revenue (principally Post Office)	35,214,000
	£198,243,000

The expenditure in the Army amounted to £28,346,000 and the Navy to £48,833,000, while the National Debt charge absorbed £24,500,000.

In 1913–14 the total amount of indirect taxation was £69,000,000, and it represented 42 per cent. of the tax revenue; the direct taxation was £93,000,000, and it represented 57 per cent. of the tax revenue.

In view of the demands which have been put forward for the institution of a Federal form of government for Ireland and Scotland, the question of the fairness of the incidence of Imperial taxation is one of very great importance, and the following tables show the result of investigations carried out by the writer in 1911–12 in order to determine the relative taxable capacity of each division of the United Kingdom:—

ESTIMATED TAXABLE CAPACITY OF ENGLAND AND WALES.*

	United Kingdom.	England and Wales.	England and Wales' percentage of U.K.
Population (census of 1911)	45,216,665	36,075,269	79·8
	£	£	
Gross assessments to income tax (1909–10)	1,011,100,344	877,888,486	86·8
Net capital of estates liable to estate duty (1910–11)	272,724,000	229,701,000	84·2
Estimated national wealth (1909)	15,882,464,000	13,716,779,000	86·4
Estimated national income (1909)	1,998,000,000	1,741,000,000	87·2
Foreign trade (1910)	1,327,225,000	1,107,709,000	83·5
Estimated net production returned under Census of Production Act, 1907 (including agricultural production and sea fisheries)	919,500,000	738,700,000	80·3

The average of the above indices is 84·03.

* "England's Economic Position and her Financial Relations with Scotland and Ireland."

ESTIMATED TAXABLE CAPACITY OF SCOTLAND.†

	United Kingdom.	Scotland.	Scotland's percentage of U.K.
Population (census of 1911)	45,216,665	4,759,445	10·5
	£	£	
Gross assessments to income tax (1909–10)	1,011,100,344	93,020,031	9·2
Net capital of estates liable to estate duty (1910–11)	272,724,000	28,313,000	10·4
Estimated national wealth (1909)	15,882,464,000	1,451,625,000	9·1
Estimated national income (1909)	1,998,000,000	174,000,000	8·7
Foreign trade (1910)	1,327,225,000	88,628,000	6·6
Estimated net production returned under Census of Production Act, 1907 (including agricultural production and sea fisheries)	919,500,000	113,300,000	12·3

The average of the above indices is 9·54.

† "The Economic Position of Scotland and her Financial Relations with England and Ireland."

ESTIMATED TAXABLE CAPACITY OF IRELAND.*

	United Kingdom.	Ireland.	Ireland's percentage of U.K.
Population (census of 1911)	45,216,665	4,381,951	9·7
	£	£	
Gross assessments to income tax (1909–10). . .	1,011,100,344	40,191,827	4·0
Net capital of estates liable to estate duty (1910–11)	272,724,000	14,710,000	5·4
Estimated national wealth (1909)	15,882,464,000	714,060,000	4·5
Estimated national income (1909)	1,998,000,000	83,000,000	4·1
Foreign or external trade (1910)	1,327,225,000	130,888,000	9·9
Estimated net production returned under Census of Production Act, 1907 (including agricultural production and sea fisheries).	919,500,000	67,500,000	7·4

The average of the above indices is 6·43 per cent. It is submitted that the average ratio in each table fairly represents the taxable capacity of the country concerned in relation to the United Kingdom as a whole.

* "Ireland's Part in the War," *Nineteenth Century and After*, May, 1917.

It will be observed from the data submitted above, that before the war the taxable capacity of England and Wales, in relation to the United Kingdom as a whole, was 84·03 per cent.; that of Scotland, 9·54 per cent.; and that of Ireland, 6·43 per cent. It is instructive to compare these figures with the total revenue, local expenditure and contribution towards Imperial expenditure from England and Wales, Scotland, and Ireland during each of the years ending March 31st, 1914 and 1917, which details are furnished below:—

	England and Wales.	Per cent.	Scotland.	Per cent.	Ireland.	Per cent.	Total.
YEAR TO MARCH 31ST, 1914.							
	£		£		£		£
Total revenue as contributed	162,491,000	83·36	21,309,500	10·93	11,134,500	5·71	194,935,000
Local expenditure . . .	66,659,500	74·80	10,105,000	11·34	12,357,000	13·86	89,121,500
Revenue contributed in excess of local expenditure .	95,831,500	—	11,204,500	—	—	—	—
Local expenditure in excess of revenue contributed .	—	—	—	—	1,222,500	—	—
Net balance available for Imperial expenditure . .	—	—	—	—	—	—	105,813,500
YEAR TO MARCH 31ST, 1917.							
Total revenue as contributed	464,255,500	84·41	61,978,000	11·27	23,766,500	4·32	550,000,000
Local expenditure . . .	66,834,000	74·86	9,763,500	10·93	12,686,000	14·21	89,283,500
Contribution towards Imperial expenditure . .	397,421,500	86·26	52,214,500	11·33	11,080,500	2·41	460,716,500

contributed by each division of the United Kingdom approximated very closely to that obtained in the year before the war, and this proves the fairness of incidence as well as the elasticity of our unitary fiscal system—a fairness and elasticity which it would be almost impossible to attain under a federal system of finance.

With regard to the expenditure upon local services, it will be noted that, while Ireland's contribution to the revenue in 1914 was only 5·71 per cent. of the total, her share of the

The above tables show that in 1914 England and Wales, with an estimated taxable capacity of 84·03 per cent., contributed 83·36 per cent. of the total revenue; Scotland, with a taxable capacity of 9·54 per cent., contributed 10·93 per cent. of the revenue; and Ireland, with a taxable capacity of 6·43 per cent., contributed 5·71 per cent. of the revenue. Notwithstanding the disturbance of the fiscal system, caused by the vast increase of £355,000,000 in the amount of revenue raised in the year to March 31st, 1917, we find that England contributed 84·41 per cent. of the revenue; Scotland, 11·27 per cent.; and Ireland, 4·32 per cent. The percentage

local expenditure was no less than 13·86 per cent. For the year 1917 Ireland's share of the revenue was 4·32 per cent., and her share of the local expenditure was 14·21 per cent. It will be observed, therefore, that Ireland's expenditure is altogether disproportionate to her revenue.

With regard to the amount contributed towards the cost of Imperial services by each division of the United Kingdom, it may be pointed out that England and Wales increased their amount from £95,831,500 to £397,421,500; Scotland increased her amount from £11,204,500 to £52,214,500; while Ireland turned a deficit

of £1,222,500 into a surplus of £11,080,500. Although this latter sum was a great improvement, it only represented 2·41 per cent. of the total contributed by the United Kingdom for Imperial services. Had Ireland's contribution been proportionate to her taxable capacity—*i.e.* 6·43 per cent.—she would have provided for the year to March 31st, 1917, a sum of about £27,000,000, instead of only £11,080,500.

It has been persistently claimed by the protagonists of Home Rule that Ireland is overtaxed. This claim cannot be sustained. Before the war Ireland did not contribute to the revenue proportionately to her income and resources. The whole tendency of war taxation is to place the burden more and more upon the direct taxpayer, and this falls much more heavily upon England and Scotland than it does upon Ireland. Again, Ireland receives twice as large a share of the local expenditure of the United Kingdom as she is entitled to on the basis of her contribution to revenue.

Summaring the conclusions arrived at above, it may be said that during the forty-four years of intensive economic development which preceded the outbreak of war, Great Britain, in common with the other leading industrial States of the world, had been accumulating immense reserves of economic strength. We had a population in the United Kingdom of 45·2 millions, together with 15 million people of the British race in the Overseas Dominions and Possessions. The total population of the Empire was 449 millions. Our merchant fleet amounted to over 20 million tons gross, only about one-half of that tonnage being employed in the carrying trade of the United Kingdom. The national wealth of the United Kingdom was about £16,500 millions, and the national income £2,140 millions.*

The national wealth of the Overseas Dominions and Possessions was £9,504 millions and the national income £1,346 millions,† making the total wealth of the Empire £26,000 millions and the total income £3,486 millions.

The United Kingdom's share of the international trade of the world was 15·9 per cent. and the Overseas Dominions and Possessions' share was 12·7 per cent., so that the British Empire transacted 28·6 per cent. of the trade of the whole world. The steam-power equipment of our industries amounted to over 10,755,000 horse-power, and our output of coal was 280 million tons per annum. Our investments abroad were valued at £4,000 millions, and they brought us an annual income of £200 millions. The manner in which these resources were converted to purposes of the war will be discussed in my second lecture.

* "Economic Relations of the British and German Empires," *Journal of the Royal Statistical Society*, July, 1914.

† "Imperial Defence and Finance," *Nineteenth Century and After*, August, 1913.

ENGINEERING NOTES.

Electric Welding as a Substitute for Riveting.—This is being tested by the United States Government at four shipbuilding yards, and so far the work is proving highly satisfactory. According to recent data, the process will increase the strength of the joint at least 25 per cent., and decrease the time of building a hull nearly 50 per cent. Eminent engineers claim that there will be a saving in labour of 60 to 70 per cent. The machine employed is the Wilson welder. At present, the plates are being lap-welded, the plates being overlapped at least two inches, sometimes more, and each edge welded down. In the future, it is the intention to butt-weld the plates (a great economy in weight, and hence in tonnage as well as in workmanship) in a manner described in an article in the *Marine Review* of May last. No reheating nor annealing is necessary. Thirty welders can do the work of 125 riveters. The Wilson welding outfit operates on what is known as the arc principle, and consists of a motor generator set, the generator of which is wound for thirty-five volts. The welding metal serves as one electrode, while the ship-plates constitute the other electrode.

Gearless Electric Locomotive for the Chicago, Milwaukee and St. Paul Railway.—A paper describing this engine, read by Mr. A. H. Armstrong, before the New York Railroad Club, states that the excellent operating results obtained during the past ten years with gearless motor locomotives on the New York Central lines have attracted increasing attention to this form of construction. The extreme simplicity in design offered by mounting the armature directly upon the driving axle, thus eliminating all gears, quills, rack-shafts, side rods, etc., has been reflected in the great reliability and low cost of maintenance. It is, therefore, an achievement of much importance to announce the entry of the gearless locomotive in the mountain grade haulage, as it can be reasonably expected that this type of construction holds promise of equally good operation in the heaviest class of railway road service. The gearless locomotive for the Chicago, Milwaukee and St. Paul extension to Seattle is equipped with fourteen axles, twelve of which are drivers and two guiding axles. The armature is mounted directly upon the axle and, with the wheels, constitutes the only dead or non-spring-borne weight of the locomotive. This weight

is approximately 9,500 lb., as compared with 17,000 lb. deadweight on the driving axles of the present geared locomotives now in operation on the Chicago, Milwaukee and St. Paul railway.

The Macchi Single-seater Fighting Aeroplane.—This is one of the most efficient flying-boats ever built, says *Aircraft*. Owing to the fineness of its construction, its light weight, and high-powered motor, it is able to ascend to an altitude of 13,000 ft. in only eighteen minutes. In a single-seater fighting machine, quick climbing power is, of course, one of the important essentials of performance, although this adaptability to climbing rapidly is not generally associated with machines of the flying-boat class. Head resistance has been reduced to a minimum, especially in regard to the inter-plane bracing. The struts and interplane bracing are similar in principle to that employed in the French Nieuport Scout—the single pairs of V struts, the narrow lower plane, and the outline of the planes themselves bear a resemblance to the Nieuport. The Macchi is provided with steel tube overhung braces, because of the area extending beyond the interplane struts. The overall dimensions of the machine are:—Span 39 ft. $4\frac{7}{16}$ in.; overall length, 27 ft. 3 in.; overall height, 9 ft. $10\frac{1}{16}$ in. There is a lifting surface of 301 sq. ft. The loading per square foot is 6·85 lb. When empty the machine weighs 1,510 lb., when fully loaded to its gross weight, 2,060 lb. There are two Fiat machine-guns, both firing forward. The engine is an Isotta-Frascini 150 h.p. The loading of the machine is 11·8 lb. per brake horse-power. It is known as the V.4B. This is a six-cylinder vertical type, with a nominal horse-power of 150, and at bench-test horse-power of 190 at 1,400 revolutions per minute. Bore, 5·2 in.; stroke, 7·1 in.; overall dimensions of the V.4B.; length, 5 ft. $0\frac{15}{16}$ in., height, 3 ft. $3\frac{1}{8}$ in.; width, 2 ft. $3\frac{15}{16}$ in. Carburettors, zenith; magneto, Marelli. The weight of the engine complete, dry, is 573 lb. Its weight per brake horse-power is 3·01 lb. Petrol is consumed at the rate of 92·6 lb. per hour; consumption per brake horse-power 7·4 oz.

The Utilisation of the Douro Falls.—The *Sol* announces the formation of a powerful company to exploit these falls, which form the frontier between Spain and Portugal. They are 300 ft. high, and are reckoned to be capable of developing 350,000 h.p., more than sufficient to supply the present annual shortage of coal, amounting to about 2,000,000 tons. The capital of the company is entirely Spanish, and amounts to £6,000,000, the greater part of which is controlled by the Banco de Bilbao. The power thus developed will be conducted to Madrid, Bilbao, and throughout Galicia, and will thus affect a large part of the Peninsula. The enterprise is expected to hasten the electrification of the railways throughout the north and east of Spain, and bring about an industrial development that will enrich the country to an incalculable degree.

Hydro-electric Power in France.—According to the *Génie Civil*, Commander H. Cohen, at the civil engineers' congress held recently in Paris, spoke on the considerable *rôle* played by water-power in war time, and said that some important results had been obtained. Before the war 750,000 h.p. with a realisable value of 800 million francs was made use of, this being about one-tenth of the total power available, which is estimated to be at least about 8 million h.p. In Switzerland, official statistics published in 1914 prove that the water-power used there is 16 per cent. of the available total. In August 1915, a start was made to intensify the resources of water-power, and manufacturers made, at the request of the Under-Secretary for War Materials, great efforts in spite of many difficulties. Since the end of 1915, the falls which had been, or were in course of development, represented at least 565,000 h.p., and those actually in harness represented 850,000 h.p. Further, at the end of 1917, 120,000 h.p. were placed at the disposal of the National Defence; 330,000 h.p. were harnessed in 1918, and the remainder will be completed during 1919 and 1920. By the end of 1921, France will have, at least 1,600,000 h.p. under control, representing a value of 1,500 million francs.

GENERAL NOTE.

THE RAW COTTON PROBLEM.—In an article which Sir Charles W. Macara contributes to the *Textile Review*, he urges the cotton industry to take in hand at once the question of establishing a reserve of cotton. The price of raw cotton has soared to an almost incredible height, and the stocks available for the mills are being greatly depleted. He fears a crisis is again arising. Any surplus that may have been grown as a consequence of the exceptional prices ruling during the past two years, and that will be accumulated as a result of the enforced idleness of so many spindles and looms owing to war conditions, should be controlled by the Governments concerned. He also insists upon the urgent need for improved baling for the American crop. It has been demonstrated that, by increasing the density of packing, millions of pounds sterling would be saved yearly. The Egyptian gin-compressed bale is, he says, the best on the market, and he strongly recommends American growers to adopt that type of bale, "not in the remote future, but now."

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, AUGUST 2, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Monday, July 29th. Present:—

Sir William Duke, G.C.I.E, K.C.S.I. (Chairman of the Committee), in the chair; T. J. Bennett, C.I.E.; Sir M. M. Bhownaggree, K.C.I.E.; Sir Valentine Chirol; Sir Frederic W. R. Fryer, K.C.S.I.; Sir H. Evan M. James, K.C.I.E., C.S.I.; Colonel Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I.: Sir Prabashankar Dalpatram Pattani, K.C.I.E.; N. C. Sen, O.B.E.; J. A. Voelcker, M.A., Ph.D., F.I.C.; Sir Frank Warner, K.B.E.; and Colonel C. E. Yate, C.S.I., C.M.G., M.P.; with G. K. Menzies, M.A. (Secretary of the Society), and S. Digby, C.I.E. (Secretary of the Section).

LECTURES ON "THE FREEDOM OF THE SEA."

The Special Lectures on "The Freedom of the Sea," delivered before the Society in May last, have been printed in pamphlet form. The pamphlet contains three lectures: I.—The Freedom of the Seas, by Gerard Fiennes; II.—The Freedom of the Sea in War, by Sir Francis Piggott; III.—The German "Freedom of the Sea," by John Leyland; and a summary of the course, by Admiral Sir Edmond T. W. Slade, K.C.I.E., K.C.V.O.

Copies of the pamphlet (price 1*s.* 6*d.*) may be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2)

EXAMINATIONS.

The results of the Intermediate (Stage II.) Examinations, held from May 6th-15th last, were sent to the centres concerned on July 29th.

It is hoped to send out the results of the Elementary Stage about the middle of August.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE ECONOMIC CONDITION OF THE UNITED KINGDOM AFTER THREE AND A HALF YEARS OF WAR.

By EDGAR CRAMMOND,
Late Secretary of the Liverpool Stock Exchange; Managing Director of B.S.T. Limited.

Lecture II.—Delivered February 25th, 1918.

In my previous lecture I gave a summary of the economic conditions of the United Kingdom immediately before the outbreak of war. It is now proposed to outline as briefly as possible the principal economic changes which occurred during the first three and a half crowded years of the war. There is not sufficient time available, nor is it necessary for the purposes of our survey, to furnish a detailed historical statement of all the economic events, and I must content myself with a brief account of the most important changes and the manner in which they were brought about.

The Empire entered upon the war with almost immeasurable reserves of economic power, but, owing to our neglect of the problem of financial preparation for war and the contempt of our people and politicians for statistics, these vast resources were utterly unorganised. The task before our Government and the nation was, first, to survey and organise the national resources; secondly, to enrol and equip an army on the Continental standard; thirdly, to transform the entire fabric of our economic life, with all its international complexities and ramifications, from peace production to war production; fourthly, to increase the output of commodities on the new basis necessitated by the war; and, fifthly, to convert the resources accumulated through three

centuries of commercial intercourse with the world into war munitions or war services.

Before the war, out of a total national income of £2,153 millions, only £77 millions, or 3·5 per cent., were allocated for the purposes of the Army and Navy. By the end of the third year of war it had become necessary to allocate for the purposes of the war £2,700 millions. As a matter of fact, part of this amount was borrowed abroad, but the United Kingdom in 1917 provided about £1,800 millions, or, say, 51 per cent. of the increased national income for the purpose of carrying on the war. The Overseas Dominions were faced with the same problem of converting their national resources from peace production to war production.

Many people have expressed a feeling of despair at the slowness with which we applied our full strength to the purposes of the war, but they do not appear to have realised the complexity—the overwhelming magnitude—of the task, and particularly the interaction of international influences on our economic life. To have instantly mobilised the whole nation on a war basis without feeling the way and providing the organisation would probably have impaired our economic strength and weakened the British staying power—the surest foundation of complete victory.

About the end of July, 1914, there were over 2,500 large British merchant ships on the high seas. Our foreign trade was running at the rate of £1,400 millions per annum. British bills for the conduct of the international trade of the world were in circulation to the value of between £400 and £500 millions. Stock Exchange loans to the extent of £90 millions were in existence, and the gold reserves at the Bank of England stood at only £38 millions. A great war, involving two-thirds of the peoples of the world, crashed into this delicate and complicated machinery, and the result was chaos for a brief period. Happily, the Government realised the magnitude of the crisis and the fact that it could only be dealt with adequately by hypothecating the credit of the country. The emergency legislation which was rushed through, notwithstanding the imperfections due to hurried drafting, proved sound, and met, to a large extent, the needs of the situation. The inherent strength of our credit system rapidly manifested itself. Our vast credits in foreign countries were called in, and during the first five months of the war our gold reserve increased from £27 millions (to which it fell on August 5th, 1914) to £69 millions on December 31st, 1914. Happily, the greatest source of our national strength, viz. our sea power, was ready, and our Navy and our merchant fleet were immediately mobilised for war. The British Navy at once took the command of the sea and kept it clear for the British mercantile marine to fulfil its vital functions.

The failure of the German armies to reach Paris and the destruction of the German naval forces in the Falkland Islands battle restored confidence, and by the end of 1914 the United Kingdom had overcome the first shock of the war and settled down to the task of organising its economic life on a war footing. The temper of the people was magnificent; workers and employers hastened to settle their outstanding differences, and an industrial truce was proclaimed which for various reasons only lasted until the early part of 1915. In 1914 there were 999 disputes, involving 448,000 workpeople and a loss of 10,111,000 working days. In 1915 there were 674 disputes, involving 446,000 workpeople and a loss of only 2,969,000 working days. In 1916 there were disputes involving 284,000 workpeople and a loss of 2,599,000 working days; and in 1917 there were disputes involving 820,000 workpeople and a loss of 5,513,000 working days. Volunteers flocked to the colours in hundreds of thousands, and by the end of 1915 no less than two and a half millions had joined the Army or Navy voluntarily, and an equally large number had, under the attestation scheme, expressed their readiness to join. On May 25th, 1916, His Majesty issued a message expressing his recognition of the splendid patriotism and self-sacrifice displayed by his people by the voluntary enlistment of no less than 5,041,000 men since the commencement of the war. It was found impracticable to continue the voluntary principle after May, 1916, and compulsory service was then instituted.

On October 27th, 1917, Lord Curzon said the total tonnage of the Navy in 1914 was 4 million tons; it was then 6 million tons. Of the mercantile marine over 3,300 vessels were engaged as mine-sweepers or patrols.

On January 14th, 1918, Sir Auckland Geddes stated that in August, 1914, the total *personnel* of the Navy was less than 150,000. The Regular Army, including Reserves and Special Reserves, amounted on mobilisation to about 450,000 men. The Territorial Force contributed some 250,000 more. Of one sort or another, therefore, there were available 700,000 soldiers. The Navy,

from 150,000 in August, 1914, stood in October, 1917, at 400,000. "The British Army to-day has on its rolls over 4,000,000 men. The actual strength of the forces to-day obviously only represents a part of the call that has been made upon our man power; to it must be added our losses . . . the effort which the British nations have made under the one item of 'Provision of men for the Armed Forces of the Crown' amounts to not less than 7,500,000. Of these, 4,530,000, or 60·4 per cent., have been contributed by England; 620,000, or 8·3 per cent., have been contributed by Scotland; 280,000, or 3·7 per cent., have been contributed by Wales; 170,000, or 2·3 per cent., have been contributed by Ireland; and 900,000, or 12 per cent., have been contributed by the Dominions and the Colonies. The remaining million men, composed of native fighting troops, labour corps, carriers, etc., represent the splendid contributions made by India and our various African and other dependencies."

The war had a very marked effect on the marriage rate in England and Wales. For 1909–13, the average number of marriages was 274,725; 1914, 294,401; 1915, 360,885; and 1916, 279,846. For the first two quarters of 1917, the returns showed heavy decreases as compared with 1915 and 1916, and they indicate that the total for 1917 will be considerably below the average for 1909–13.

The births in England and Wales declined from 881,890 in 1913 to 814,614 in 1915 and 785,520 in 1916. There was a decrease in 1915 of 7·6 per cent. on 1913, and in 1916 a decrease of 10·9 per cent. on 1913, and for the first three quarters of 1917 a decrease of 23 per cent. on 1913.

In Scotland the decrease was relatively smaller, but still very substantial.

**Death Rate.*—The following is a statement of the deaths in the civil population only for the years 1913–17:—

	England and Wales.	Scotland.	Ireland.	United Kingdom.
1913	504,975	73,069	74,694	652,738
1914	516,742	73,557	71,345	661,644
1915	553,476	81,157	76,151	710,784
1916	499,145	70,642	71,391	641,178
1917 (1st half)	291,561	—	—	—

The main feature of this table is the rise in the death rate in 1915, followed by a heavy fall in 1916, and a large rise again in the first half of 1917.

Excess of Births over Deaths.—During the period from July, 1914, to June, 1917, the excess of births over deaths for the United Kingdom was 904,000. *"This excess is very considerably greater than the total loss of lives by English, Welsh, Scotch and Irish soldiers and sailors during the period of the war. Migration, which in normal years plays an important part in determining the increase or decrease in the population, has, during the war, ceased to such an extent as to make its influence of comparatively little account. As a matter of fact there is a small balance of gain to the United Kingdom from this source, amounting for the period in question to 115,000 persons of both sexes and all nationalities. The gain is generally due to the migration of Belgian refugees."

After six months of war, it became apparent that the arrangements for the supply of munitions were wholly inadequate, and that, in order to obtain a sufficient output and to provide equipment for the new armies, it would be necessary to mobilise the whole of the industrial resources of the nation; and on June 25th, 1915, the Ministry of Munitions was created. The Act provided that there should be no strike or lock-out at works engaged in the supply of munitions; that any disputes must be referred to arbitration; that there should be Government control of workshops and Munition Courts would have power to inflict penalties; that trade union regulations restricting output should be suspended and employers' profits limited.

"The conditions under which the Ministry of Munitions was created were those of intense war emergency—the vital need of supplying the armies in the field with adequate, abundant, and finally overwhelming supplies of ammunition, guns, and material of all kinds—necessitated and justified every expedient and the suspension of all ordinary rules.

"The immense and thus far unmeasured resources of the United Kingdom afforded an ample field for the enterprise and energy of departmental direction, and for the organising capacity and bold initiative of British business men. Supplies were freely drawn from all parts of the Empire, and purchases from neutral states were used to supplement any deficiencies. As new needs arose, they were met. Department was added to department. Military requirements were not only satisfied, but anticipated, and vast programmes were successfully carried through. The British Army became the

* Extract from "Vital Statistics as affected by the War." —Sir Bernard Mallet.

* Extract from "Vital Statistics as affected by the War." —Sir Bernard Mallet.

best equipped and most formidable army in Europe."

The department at the beginning of 1917 undertook the Aircraft Supply Department, and in addition to guns and ammunition and all forms of army equipment, it became responsible for "tanks," agricultural implements, shipbuilding, and many other supplies. On June 28th, 1917, the Minister of Munitions, then Dr. Addison, gave an interesting review of the work of the department, in the course of which he stated that in March, 1917, the capacity for the production of high explosives was more than four times that of March, 1916, and twenty-eight times as great as that of March, 1915.

In an official memorandum issued in August, 1917, it was stated that the total staff at headquarters of the Ministry of Munitions was 13,500, and that this single Department of State was then employing two million persons, of whom about 670,000 were females; and that it was in contact at innumerable points with almost every business in the country, and was responsible for expenditure which might well amount to between £600 to £700 millions a year.

The war naturally caused a tremendous disturbance in the industrial life of the country. The Census of 1911 showed that, at that date, there were 35,750,000 persons occupied and unoccupied, aged 10 years and upwards. Of this total, 2,886,000 males and 12,704,000 females were described as retired or unoccupied, leaving 14,307,000 males and 5,851,000 females occupied. By the end of the first three years of the war, the number of men who had joined the Army and Navy was about 5,500,000, and as the great bulk of these were withdrawn from production, the total number of men and boys left in industrial occupations, including munitions, was a little over 9 millions. On the other hand, the number of women occupied in industry, including munitions, increased from 3,345,000 in July, 1914, to 4,766,000 in November, 1917, an advance of 1,421,000, or 42·5 per cent. It is instructive to note that during the same period the number of women employed in domestic service and small workshops decreased by 400,000, so that the net increase was 1,021,000. It is believed that about 670,000 women were employed on munition work, and 632,000 were engaged on other Government work, such as the manufacture of clothing and food for the troops (*Labour Gazette*, November, 1917).

Notwithstanding this vast withdrawal of man-power for naval and military service, the production of the country appears to have been not only fully maintained but actually increased. In the autumn of 1917 the Minister of Agriculture stated that the United Kingdom was the only belligerent which had increased its production of food during the war.

Lord Aberconway stated on September 27th, 1917, that "if you take the nation as a whole, our man power in production has increased 30 per cent. over normal times, and with 30 per cent. loss of a male population to do it with. Now, these are very remarkable figures, and I need hardly point out that but for the valuable help women have given us, these figures would have been impossible."

Dr. Addison stated on June 28th, 1917, that before the war the output of steel in this country had been more or less stationary at a little over 7 million tons per annum. The output then (June, 1917) was about 10 million tons, and he should be disappointed if they had not reached a 12-million ton output by the end of 1918.

With regard to coal, the production appears to have been well maintained. In September, 1917, the Chief Inspector of Mines reported that 998,063 persons were employed in 2,847 coal mines in the United Kingdom, as compared with 953,642 persons the previous year. The total output of coal in 1916 was 256,375,000 tons, as compared with 253,206,000 tons in 1915. Up to the end of March, 1916, 282,500 miners (or 25 per cent. of the labour employed at collieries at the outbreak of war) had joined the colours, and this number had increased to over 288,000 at the end of June. The replacements up to March, 1916, amounted to 116,900, leaving a net reduction of 165,300, or 14·8 per cent.

For the first nine months of 1917 the output was 187,750,000 tons, or 5 million tons less than in the corresponding period of 1916, and the production for the whole year will probably be between 247 and 250 million tons. The following table shows the production of coal in the United Kingdom, the exports (including bunker coal) and the home consumption for each of the years 1913, 1914, 1915, 1916 and 1917 (estimated):—

	1913.	1914.	1915.	1916.	1917.
Production	289,338,000	265,664,000	253,206,000	256,348,000	247,250,000
Exports and Bunkers .	98,338,000	83,027,000	59,952,000	55,000,000	48,250,000
Home Consumption .	191,000,000	182,637,000	193,254,000	201,348,000	199,000,000

It will be observed that although there has been a substantial reduction in the output of coal, the falling off in exports and bunkers has been still greater, with the result that the home consumption of coal in 1917 was about 5 per cent. greater than in 1913. As there has been a great reduction in the consumption of coal for domestic purposes, it may be safely assumed that the amount of coal used for industrial purposes has materially increased during the war, and this means in turn a corresponding increase in the production of the country, including, of course, munitions. In March, 1917, the Government took over all the coal mines in the kingdom in order to have complete control of the coal production and distribution. The price of coal at the pit's mouth was regulated so as not to exceed by more than a certain sum per ton (viz. 9*s.* in South Wales and Dean Forest and 6*s.* 6*d.* elsewhere) the price in 1913–14. This was absolutely necessary in order to secure the smooth working of the industry and to meet the charge of profiteering. Railway transport at the time was also giving the Government grave concern. In the case of coal alone 250 million tons were carried over the railways annually, and it was estimated by the Coal Controller that by having control of all the output of the mines, and being able to determine its destination—in other words, by bringing the consumption of coal as nearly as possible to the source—it was possible to save, roundly, 700 million ton-miles per annum.

There is an intimate relation between the national production and the consumption of Board of Trade units of electricity, and I have had the figures taken out showing the Board of Trade units sold by the municipal authorities for the year to March 31st, 1917, as compared with the number sold during the year to March 31st, 1914. The results are as follows:—

Board of Trade units sold for year to March 31st, 1917	1,298,000,000
Board of Trade units sold for year to March 31st, 1914	770,000,000
Increase	528,000,000 or 68·6 per cent.

It has been ascertained during the recent discussions as to the practicability of "linking up" generating stations, etc., that the average output of electricity before the war was progressively increasing at the rate of approximately 20 per cent. per annum—that is to say, if 1912 represented 100 per cent, 1913 would be 120 per cent., and 1914, 20 per cent. on 120 per cent., and so on. The returns as to electricity, the production of coal, the production of steel, the agricultural production, all point to the same conclusion, namely, that during the war there has been an increase in the production of the United Kingdom; and I am convinced that since August, 1914, our power of production has increased by at least 30 per cent.

The problem of financing the war was naturally the most formidable of the economic tasks which had to be undertaken by the Government. Our war expenditure began at an average of £1 million per day. As the Army grew and the scope of our activities steadily widened, and the prices of commodities and foodstuffs advanced, the war expenditure rapidly increased. From August, 1914, to March 31st, 1915, it averaged £2,050,864 per day; for the year to March 31st, 1916, it averaged £4,271,666; for the year to March 31st, 1917, it averaged £6,022,222; for the half-year to September 30th, 1917, it averaged £7,500,000 per day. Before the war the requirements of the Army were supplied by contracts based on a system of competitive tendering, but the inability of supply to keep pace with the demand, and the consequent rise in prices, necessitated a revision of the relationship between the Government and industry. It was agreed that the Army and Navy should have the first call on the resources of the country, and that the prices to be paid by the War Office should be regulated, not by market prices, but by the cost of production, plus a reasonable rate of profit. To determine the manufacturer's expenses a special Costings Department was established.

The result of the fixing of prices by examination of costings, in conjunction with a priority scheme by which manufacturers are required to complete Government contracts before dealing with private customers, was to secure to the Government service the full industrial resources of the country at fairly reasonable rates, but it was obvious that if the Government were to control the manufacturers' prices they must also control the cost of raw materials. Direct purchases in the world's markets and the elimination of the middle man were resorted to on a large scale. This naturally created a strong feeling of resentment, and in May, 1917, the Merchants' Committee of the London Chamber of Commerce reported that the effects of the Government action in many cases had tended to stifle and partially ruin trade. It was pointed out that it was impossible for any Government to regulate the world's commerce. High prices, it was claimed, restricted

consumption and checked waste. It was urged that high prices were the only hope of increasing production, and only thus would famine prices be finally prevented. If commerce was rendered unprofitable it would cease, and it was urged that the effect of Government control in many cases had been to divert large supplies to the free markets. By the end of the first three years of war the following commodities and foodstuffs were under Government control:—Coffee, coal, copra, diamonds, feeding stuffs, grain, jute and its fabrics, leather, maize, meat, metals, including iron and steel, oil, seed, paper, petrol, preserved meat, rubber, sugar, tanning materials, tobacco, wood and wool.

One of the largest operations undertaken by the Government was the control of the grain market. The Royal Commission on Wheat was appointed on October 11th, 1916, to maintain the supplies of wheat in this country, but later on the scope of its activities was enlarged to cover maize, barley, rice, tea, meal, grain, flour, lentils, cheese, and peas. An agreement was subsequently entered into between the British, French, and Italian Governments constituting a body, called the Wheat Executive, to buy grain for the three countries. The objects of the agreement were (1) to avoid competition in buying and (2) to prevent waste in the use of shipping. The Wheat Commission was charged with the responsibility of buying for all three countries, of dividing the charges among them in the right proportions, of shipping from each exporting country, and then of seeing by a careful system of accounts that each country paid its due share of the cost of the grain received. The Commission has conducted its business on trade lines. The cash trading capital and commission in August, 1917, was £48 millions, and the Commission had then drawn altogether £67 millions from the Treasury.

The largest purchase made by the Commission was 14 million quarters of wheat direct from the Australian Government, involving a sum of about £26 millions. Shortly after this contract was made the shipping scarcity became acute, and the great bulk of this wheat was still in Australia when the Committee* made its report in October, 1917. The Commission has largely increased the reserve of wheat which it took over from the Board of Agriculture on its appointment, and a fairly heavy loss appears to have been incurred in connection with the storage of these reserves. The decision of the Food Controller that wheat must be sold at a price allowing the public to purchase a 4 lb. loaf for 9*d.* will cost the Commission £45 million a year. The arrangement for the supply of meat to the allied armies, and when not so required, to the trade, involves very large transactions. The payments under this head for the year 1915–16 for purchase, freight, and storage amounted to £31,386,818, and the receipts for sales to £27,838,749, leaving a balance of £3,548,069, representing meat in stock plus issues not paid for. The control of the sugar supply accounted for still larger figures. For the year 1915–16 the receipts from the sale of sugar were £34,840,523, and the payments were £26,432,369, leaving a balance of receipts of £8,408,153; but in 1914–15 the payments exceeded the receipts by £7,105,747, so that there was a net excess of receipts over payments in the two years of £1,302,405.

As the war progressed and the scope of the Government's activities widened, more and more trade enterprises were taken over, and the Chancellor of the Exchequer, when explaining the increase in the expenditure on October 30th, 1917, said the largest item of the increase, viz. £74,500,000, was incurred in connection with the purchase of supplies of raw materials, such as wool, hides, and timber, and foodstuffs, such as wheat and sugar.

The first War Budget was introduced by Mr. Lloyd George on November 17th, 1914. Its main features were the doubling of the income tax and super tax, an additional ½*d.* on a half-pint of beer, and 3*d.* per pound on tea.

Mr. Lloyd George presented the second War Budget on May 4th, 1915. It contained no new taxation proposals. The expenditure for the year 1914–15 amounted to £560,474,000 and the revenue to £226,694,000 (£189,305,000 from taxes and £37,389,000 from non-tax revenue), leaving a deficiency of £333,780,000.

The third War Budget was presented by Mr. McKenna on September 21st, 1915. Under this Budget the following new taxation was adopted:—

Income Tax.—40 per cent. added to the existing rates; only half of the increase (20 per cent.) to be imposed for the year to March 31st, 1916. The exemption limit to be reduced from £160 to £130, and the abatement limit to be £120 where it was £160, and where it was £150 or £120 it would become £100. Provision was made to enable the payment of the tax by

* Select Committee on National Expenditure. Second Report.

instalments in certain cases. The alterations in the income tax were expected to produce an additional £11,274,000 in 1915–16 and £44,400,000 in a full effective year. Certain additions were also made to the super tax.

Excess Profits Tax.—This tax really constituted an additional income tax. The trades or professions liable to the tax included any carried on in the United Kingdom or owned or carried on in any other place by persons ordinarily resident in the United Kingdom. Farmers, officials, and professional men were exempt. Any business or trade to which the tax applied was liable to pay to the Exchequer a sum equal to 50 per cent. of the amount by which the profits for the "accounting period" exceeded by more than £200 the defined pre-war standard of profits. The tax only applied to periods of account terminating after August 4th, 1914, and before July, 1915. Profits earned in periods ending later were to be dealt with by subsequent legislation on the same lines. The new tax was estimated to produce £6,000,000 in 1915–16 and £37,000,000 in a full effective year.

Customs and Excise.—Duty on sugar increased from 1*s.* 10*d.* per cwt. to 9*s.* 4*d.* per cwt. Tea, tobacco, cocoa, coffee, chicory, and dried fruits, an all-round increase of 50 per cent. on the existing duties. Motor spirits, an increase of duty of 3*d.* per gallon.

Imported Luxuries.—An *ad valorem* duty of 33⅓ per cent. or its equivalent in the form of a specific tax—that is to say, on weight instead of on price—on motor cars, motor cycles, cinema films, clocks, watches, musical instruments, plate glass.

Post Office, etc.—Some important changes in postal telegraph and telephone rates were proposed, but the most important of all—namely, the proposed abolition of halfpenny postage—was abandoned as a result of pressure brought to bear upon the Government.

The fourth War Budget was introduced by Mr. McKenna on April 4th, 1916. It provided for a graduated increase of the income tax, making the maximum rate 5*s.* in the £. The duties on sugar, cocoa, coffee, and chicory were appreciably advanced, while new taxes were levied on matches and table waters. The expenditure for the year to March 31st, 1916, amounted to £1,559,158,000 and the revenue to £336,767,000 (from taxes £290,088,000, non-tax revenue £46,679,000), leaving a deficiency of £1,222,391,000.

On May 2nd, 1917, Mr. Bonar Law introduced the fifth War Budget. Under this Budget the excess profits duty was increased from 60 per cent. to 80 per cent. as from January 1st, 1917, and the entertainments tax was increased substantially.

The expenditure for the year to March 31st, 1917, was £2,198,113,000 and the revenue £573,428,000 (from taxes £514,105,000, non-tax revenue £59,323,000), leaving a deficiency of £1,624,685,000.

In order to show the change which the first three years of war have brought about in the position of the national finances, I have prepared the following table, which contains particulars of the actual receipts and expenditure for the year 1913–14 and the estimated receipts and expenditure for the year 1917–18:—

RECEIPTS.

Actual, 1913-14. £		Estimated, 1917-18. £
35,450,000	Customs	70,750,000
39,590,000	Excise	34,950,000
27,359,000	Estate, etc., Duties	29,000,000
9,966,000	Stamps	8,000,000
2,700,000	Land Tax and House Duty	2,600,000
47,249,000	Income Tax, including Super Tax	224,000,000
	Excess Profits, including Munitions Levy	200,000,000
715,000	Land Value Duties	400,000
163,029,000	Total Receipts from Taxes	569,700,000
35,214,000	Non-Tax Revenue, including Post Office, etc.	68,900,000
	Total Revenue	638,600,000
	Deficiency	1,651,781,000
198,243,000		2,290,381,000

EXPENDITURE.

Actual, 1913-14. £		Estimated, 1917-18. £
24,500,000	National Debt Services Inside the Fixed Debt Charge	17,000,000
	Outside do. . . (*c*)	194,500,000
9,734,000	Payments to Local Taxation A/c.	9,700,000
3,089,000	Other Cons. Fund Services, etc.	1,695,000
37,323,000	Total Cons. Fund Services	222,895,000
28,346,000	Army . . . (*a*)	15,000
48,833,000	Navy . . . (*a*)	17,000
	Ministry of Munitions . . . (*a*)	1,000
53,901,000	Civil Services	61,224,000
4,483,000	Customs, Excise and Inland Revenue	5,249,000
24,607,000	P.O. Services	25,980,000
160,170,000	Total Supply Services	92,486,000
750,000	Votes of Credit Balance . . (*e*)	1,975,000,000
198,243,000		2,290,381,000

(*a*) Nominal provision, the substantive provision being made under Votes of Credit.
(*c*) Including estimated interest on new Debt to be credited in 1917–18.
(*e*) The three war services account for £1,433,500,000.

The whole basis of taxation has been disturbed by the war. In 1913–14 direct taxation amounted to £93 millions and represented 57 per cent. of the total tax revenue. For the year 1917–18 direct taxation, including excess profits duty, will amount to £466 millions, or 82 per cent. of the total taxation. It will be seen, therefore, that the burden of war taxation has fallen almost entirely upon the direct taxpayers. The proportion of the total expenditure raised by (1) borrowing and (2) revenue—that is, taxation and Post Office, etc., during each of the years 1915, 1916 and 1917—was as under:

For the year to March 31st, 1915 (which included the first eight months of the war), the revenue was £576·7 millions, of which amount £405 millions were borrowed and £171·7 millions, or 29·7 per cent., raised by revenue.

For the year to March 31st, 1916, the total sum received was £1,501·3 millions, of which £1,164·5 millions were borrowed, and £336·7 millions, or 22·4 per cent., was raised by revenue.

For the year to March 31st, 1917, the amount received was £2,199 millions, of which £1,625·5 millions were borrowed and £573·4 millions, or 26·8 per cent., raised by revenue.

On October 30th, 1917, Mr. Bonar Law said the total amount of our National Debt was between £4,900 and £5,000 millions. He would take it at £5,000 millions. They were entitled, he said, to deduct from this sum the amount of the advances to our Allies and the Dominions. These items came in the case of the Allies to £1,100 millions, and in the case of the Dominions to £160 millions. They were entitled to deduct another item, that was the gift of the Indian Government to the Empire in connection with the war, which was £100 millions. Those items together amounted to £1,360 millions. That brought down the total amount of the debt to £3,674 millions. The National Debt at the beginning of the war was £645 millions, so that the increase of debt due to the war was about £3,000 millions.

The total gross debt of £5,400 millions appears to have been raised in the following form:—

Debt on December 8th, 1917.*

Funded Debt, principally Consols	£317,787,000
Terminable Annuities	24,045,000
Unfunded Debt—	
3½ per cent. War Stock	62,746,703
4½ ,, ,, ,, ,,	19,989,842
5 ,, ,, War Loan	2,066,988,385
4 ,, ,, ,, ,,	52,418,250
3 ,, ,, Exchequer Bonds, 1920	21,650,700
War Savings Certificates	101,587,016
War Expenditure Certificates	23,561,000
5 per cent. Exchequer Bonds, 1919–20–21	156,913,415
6 ,, ,, Exchequer Bonds, 1920	141,744,780
Other Debt, including Anglo-French Loan in U.S.	849,773,040
Ways and Means Advances	253,155,500
Treasury Bills (including £12,995,000 pre-War	1,059,525,000
5 per cent. Exchequer Bonds, 1922	82,209,400
National War Bonds (Post Office and Bank of England)	154,200,000
	£5,388,295,031

* Daily Telegraph, December 17th, 1917.

It will be observed that out of a total gross debt of £5,388 millions outstanding on December 8th, 1917, only £2,543 millions, or 47 per cent., had then been funded into War Stock, etc., the principal items of the unfunded debt being:—

Treasury Bills	£1,059,000,000
Other Debt	849,000,000
Ways and Means Advances	253,000,000
Exchequer Bonds	402,000,000
	£2,563,000,000

It is a matter of some urgency that a large proportion of these last items should be converted into War Loan, and this operation would doubtless be greatly facilitated if arrangements could be made whereby credit might be obtained without having to sell War Stock.

The Budget estimate provided for an expenditure of £6,275,000 per day, including £864,000 carried on the estimates and £5,411,000 on the votes of credit. In moving the vote of credit on October 30th, 1917, the Chancellor of the Exchequer stated that the expenditure for the half-year exceeded the Budget estimate by £1,237,000 per day, or an aggregate for the half-year of £222,500,000. If this rate is maintained throughout the year the total expenditure will be £2,735 millions, or £455 millions more than the Budget estimate. The Chancellor of the Exchequer explained the increases under the following heads:—Increase of monies in agents' hands abroad, £15,500,000; Advances to Dominions, £24,000,000; Purchases of foodstuffs, raw materials and ships, £74,500,000; Loans to Allies, including moneys spent by Ministry of Munitions, £65,000,000; and War Office increase, £39,000,000.

The cost of fixing the price of the loaf at 9*d.* will add £45 millions to our expenditure. The increase of pay to soldiers and sailors will add £65 millions this year, and the payments to farmers under the Potato Order will account for a further £5 millions. There seems to be no

prospect of the expenditure diminishing. The additional allowances in connection with old age pensions will call for £5,320,000 this year and about £6,000,000 per annum thereafter. Aviation will call for increased expenditure. The number of men serving abroad is continually increasing. A large number of Indian troops are now serving in Mesopotamia. As our armies advance, the cost of communications —railways and bridges—are bound to increase.

But on the other hand it is already evident that there will be a very large increase in the revenue from taxation. Excess Profits Duty was estimated to produce £60 millions more than in 1916–17, but by December 31st, 1917, it had already produced £69 millions more than in the corresponding period of the previous year. Income tax was estimated to yield £19 millions more for the whole year, but by December 31st, 1917, the yield was £15·5 millions more; while miscellaneous sources yielded a revenue of £46·6 millions against £11·7 millions in the corresponding period last year. Customs and Excise were estimated to yield £21 millions less. By the end of December the yield was only £11·1 millions less. I estimate that the total revenue for the year will amount to at least £726,000,000, or £153,000,000 more than for the preceding year.

Several attempts were made to control expenditure and check waste. In 1915, a Retrenchment Committee was appointed which made a few feeble recommendations for economies, but the scope of the inquiry was so limited that from its inception it was doomed to ineffectiveness. The House of Commons became alarmed at the growth of expenditure when on June 11th, 1917, the Chancellor made the announcement that for the first nine weeks of the current financial year our expenditure had averaged £7,884,000 per day, and a Select Committee was appointed on July 25th, 1917, "to examine the current expenditure defrayed out of monies provided by Parliament, and to report what, if any, economies consistent with the execution of the policy decided by the Government may be effected therein," and Mr. Herbert Samuel was appointed chairman. Two reports were issued at the end of 1917, and their general conclusions may be summarised in the statement that the financial control of expenditure is insufficient, and that the maintenance of the staying power of the country during a long war requires that "considerations of cost should be put on a different plane from that which they have hitherto occupied." But the House found itself quite helpless to stem the growth of expenditure. It looks very much as if nothing can be done effectively to stop the growth of expenditure until the workers become sufficiently educated in political economy to realise that this constant putting up of wages is a real disadvantage to the working classes as a whole and that it really comes out of their own pockets. Since the Committee was appointed in August, 1917, ten increases of expenditure were incurred, namely, £45,000,000 in order that the loaf might be sold at 9*d.*; £5,000,000 bonus to potato growers; £65,000,000 increase of pay to soldiers; £7,350,000 increased pay to Army officers; £20,000,000 bonuses to miners; £40,000,000 to munition-workers; £10,000,000 to railway workers; £3,000,000 to civil servants; £170,000 to Irish teachers and £400,000 to Irish police; the total making an annual increase of £195,920,000.

From 1870 down to 1914, agriculture was a declining industry. The decrease in tillage amounted to 3,883,000 acres, or 27 per cent., in England and Wales; 196,000 acres, or 6 per cent., in Scotland; and 663,000 acres, or 12 per cent., in Ireland. The number of persons engaged in agriculture at the census of 1871 was 2,487,900, and at the census of 1911 only 1,926,687. The estimated value of the agricultural production declined from £259,800,000 in 1873 to £208,000,000 in 1908, but it is probable that owing to the fall in the price of agricultural production the actual amount of foodstuffs produced in 1908 was larger than in 1873. It may be estimated that whereas in 1872 we produced 57 per cent.* of the total food consumed, the production of food in 1913 was only 42 per cent. of the total consumption. That is to say, when war broke out we were confronted with the fact that we only grew sufficient food to feed the population three days out of every week. Owing to the fact that during the first eighteen months of the war our mercantile marine continued to perform its functions almost as in time of peace, the gravity of this dependence upon foreign supplies of food was not fully appreciated, and the Government did not take any steps in the early stages of the war to control the farmers. The necessity of increasing the home production of food was, however, generally recognised, and at the beginning of 1917, in order to encourage farmers, a price guarantee was given for wheat, oats and potatoes.

* Professor Starling, letter in the *Times*, February 5th, 1918.

One of the first fruits of this change in the national agricultural policy was the passing of the Corn Production Act. On April 24th, 1917, Mr. Prothero, in moving the second reading of this measure, said national safety demanded a larger supply of home-grown food, and national welfare demanded that we should retain as much as possible of the rural population. From these two points sprang the two principal features of the Bill, viz., a minimum price and a minimum wage. The Act, which is in four parts, proposes to obtain an increase of the arable area by means of a minimum price for wheat and oats, as follows:—

MINIMUM PRICES FOR WHEAT AND OATS.

	Wheat price per quarter. *s.*	Oats price per quarter. *s.*	*d.*
1917	60	38	6
1918, 1919	55	32	0
1920, 1921, 1922	45	24	0

Part 2 provides for the institution of a minimum wage of 25*s.* per week for agricultural workers and for the creation of wages boards to settle disputes as to wages. Part 3 provides that no landowner shall be allowed to use for his own private advantage the guarantee of minimum prices given by the State for the public benefit. Part 4 provides that the State shall have power to secure that the land is properly cultivated.

Mr. Prothero said if we could grow at home 82 per cent. of all the food we require, we should be safe in an emergency. We could obtain that result if we could add eight million acres to the existing arable area—that is to say, if we increased it from 19 million acres to 27 million acres—and the number of additional men who would be required on the land would be about 250,000.

The Corn Production Act was, however, much less ambitious. It proposed to make such a substantial increase in the arable area as was possible within the limits of six years. In 1914 the total amount of acreage under corn crops, wheat, oats, and barley was 7,678,000. In 1915 it had risen to 8,041,000, but as 250,000 agricultural workers had enlisted up to the end of 1915, the labour difficulty by that time had become acute, and the acreage in 1916 decreased by about 300,000 acres. In 1917 there was an addition of 330,000 acres in England and Wales and 750,000 acres in Ireland. The various measures taken did result in a moderate expansion in the home production of food, and the following table shows the increase in the area under corn crops, potatoes, etc., between 1914 and 1917*:—

	1914. 1,000 acres.	1917. 1,000 acres.	Increase or Decrease. 1,000 acres.
Arable land	19,414	19,652	238
Wheat	1,906	2,104	198
Barley	1,873	1,797	– 76
Oats	3,899	4,762	863
Total corn crops	7,678	8,663	985
Potatoes	1,209	1,365	

The result of this extension of acreage of the food supply is indicated in the table appended, which gives the total production of corn crops and potatoes at each of the harvests 1914–7:—

	1914. 1,000 qrs.	1915. 1,000 qrs.	1916. 1,000 qrs.	1917. 1,000 qrs.
Wheat	7,804	9,239	7,472	7,979
Barley	8,065	5,862	6,612	7,185
Oats	20,664	22,308	21,334	23,964
	36,533	37,409	35,418	39,128
	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Potatoes	7,476	7,540	5,468	8,603

The average price of wheat in the second week of December, 1917, was 70*s.* 7*d.*, as compared with 42*s.* 1*d.* in the corresponding week of 1914. The position with regard to live stock is not satisfactory. The figures are as under:—

	1914.	1917.
Horses	1,851,042	1,870,770
Cattle	12,184,505	12,342,268
Sheep	27,963,977	27,770,553
Pigs	3,952,615	2,998,657

It is gratifying to see an increase in the number of horses and cattle, but the falling off in pigs is serious, and the decrease in the number of sheep is also unsatisfactory.

Farmers were treated very lightly with regard to the income tax. Formerly they were assessed to income tax at one-third of their rent. Since the war the assessment under Schedule B has been raised to the amount of the whole rent, but farmers do not pay any excess profits duty. With regard to the bonus to potato-growers, Mr. Clynes said (November 13th, 1917, House of Commons): "The charge upon the Exchequer involved by the War Cabinet's decision to compensate growers who sell potatoes of the 1917 crop below the guaranteed price of £6 per ton is estimated not to exceed £5,000,000."

* "Prospects of the World's Supplies of Food after the War."—Sir R. Henry Rew.

The value of the agricultural output in 1908 was about £208 millions. The agricultural index numbers have been as follows:—1913, 112; 1914, 111; 1915, 138; 1916, 178. The value of the production for 1917 may therefore be estimated at £400 millions. The labour and other difficulties with which the farmers have had to contend have, of course, been very great, but on the whole the result of the effort to increase the home production of food is disappointing, and it does not appear, in spite of the extraordinary inducements held out to farmers, that at the end of the war we shall have materially emancipated ourselves from dependence upon foreign food supplies.

(*To be continued.*)

DAMASCENE STEEL.

By Colonel Nicholas T. Belaiew, C.B.

One of the many articles which contributed to the world-importance of Indian trade was the famous Indian steel. It appeared in Western Europe during the Middle Ages, under the name of damascene, or Damascus steel. By another trade route through Persia and the Caucasus it found its way to Russia, under the Arabian name of "foulad," which the Persians spelt as "poulad," and the Russians as "bulat."

We find, for instance, in the journal of Prince Zvenigorodsky, the Russian Ambassador in Persia, the following words of the Shah Abbas: "Helmets and shishaks are manufactured in our country, but a good 'bulat' is brought here from the Indian kingdom."

On the other hand, from the twelfth century comes the testimony of the Arab geographer, Edrisi: "The Hindoos excel in the manufacture of iron and in the preparation of those ingredients along with which it is fused to obtain that kind of malleable iron usually styled Indian steel. They also have workshops wherein are forged the most famous sabres in the world."

The iron and steel industry was highly developed in ancient India. A witness to this exists not only in the famous wrought-iron pillar of Delhi, but in many other specimens, some of them at least being undoubtedly high carbon crucible steels.

To this last category belonged the wootz, or small cakes of carbon steel, from which the damascene blades were manufactured. Some of such cakes were investigated by Réaumur, but he found nobody in Paris who could forge them. Some others were presented to the Royal Society by Dr. Scott, of Bombay, and brought to this country by Dr. Pearson. Faraday took a keen interest in them, and his investigation of alloy steel, conducted in conjunction with Stodart, was the result.

Subsequent researches of General Anossoff, Professor Tchernoff, and the author, led to show that damascene steel was a very pure high carbon crucible steel, with excellent mechanical qualities and a splendid watering.

In his recent paper on this subject to the Iron and Steel Institute, the author explained that the splendid watering of the Oriental blades showed the amount of mechanical treatment the original cake was subjected to; this watering, from the point of view of modern metallography, was its macrostructure. In order not to spoil this watering the Oriental maker never dared to exceed the temperature of about 700 degrees.

One of the many results of this enforced carefulness was the spherodising of cementite into globulites, and the subsequent ductility of the alloy, which struck both the ancient and modern explorer.

The author wishes to draw the attention of all interested in the production of high carbon and alloy steels to the many possibilities, especially from the point of view of after-war trade, which the damascene steel, or, we may better say, the "damascene process," offers to the steel-maker in this country and in the Indian Empire.

SIGNALLING IN MINES.

A great deal depends on satisfactory signalling down a mine, as coal, when "won" from the coal-seam or face, is not "effectively got" until it has been tubbed and raised to the surface of the pit.

Ineffective signalling means delays and loss of output, which at the present moment is a vital matter. Especially is this so, on account of the very large comb-out which is taking place in all mines throughout the country. There is also the factor of "safety" in signalling. The disaster at Senghenydd Colliery was supposed to be caused through open sparking between signal wires. Many people have made experiments to try to overcome such sparking or break-flash, but such efforts have been mainly in the direction of curing sparking on the old-principle apparatus and existing designs of signalling system gear, and this has added to the already cumbersome, and to some extent complicated, apparatus.

It has been left to Mr. W. de M. Landon, A.M.I.E.E., Member of the Association of Mining and Electrical Engineers, to evolve a system where only one wire is employed, with the earth for return, and where only six volts pressure actuates the system. There is no possibility of sparking on the system (break-flash is cut out between wires, as only one wire is employed), and a two years' trial in a network of Lancashire mines has proved the system absolutely satisfactory. A system of relays operates the signalling bells, and a piece of apparatus called an "interrupter" (which swings on the line wire) actuates the relays. The system is one that colliers can easily understand. Only very small sets of batteries are needed, and the system uses far less battery power than any other known system.

STUDY OF AMERICAN PAPER PULPS.

A report of recent scientific study of paper pulps, particularly those of American manufacture, has been published by the United States Bureau of Standards as Technologic Paper No. 88. Samples of pulps, each representing a different method of preparation, have been examined to determine their chemical properties. The loss in weight produced by reagents, causing hydrolysis and oxidation, and the gain in weight when nitrated have been determined with the same pulps. The effect of sunlight, temperature, and ozonised air on the chemical constants of ground wood has been ascertained.

Much work had already been done both with the woods from which the pulps are produced and with the pulps themselves in studying the properties of the fibres, and in seeking to find means of judging the paper-making value by laboratory tests in advance. The results are scattered over a wide range of chemical literature, and for the most part are concerned with pulps produced in other countries. The present work has been carried out chiefly with typical American pulps produced by the several well-known methods in order to ascertain their chemical characteristics as far as possible with the few reliable quantitative methods available. Copies of the paper may be obtained at 5 cents (2½*d.*) each from the Superintendent of Documents, Government Printing Office, Washington, D.C.

KAPOK.

The use of kapok and its substitutes has undergone considerable expansion during the present war, particularly as a filling material for lifebelts and waistcoats and other forms of life-saving appliances. In view of the utilisation of kapok and other flosses for this purpose, an investigation has been carried out by Messrs. C. F. Cross and E. J. Bevan, with the object of devising a rapid method for determining the approximate value of representative samples, and the results have been published in *Journ. Soc. Dyers* (1916, 32. 274).

It has usually been assumed that the impermeability of the material to water is due to the presence of such constituents as oil, wax and resin in the wall of the fibre; but it has now been found that this is not the case. The amounts of such constituents very considerably in different samples, but the variations do not show any correlation with the resistance of the fibre to the admission of water, and the resistance is not appreciably affected by the removal of these substances.

Three tests are recommended for the rapid determination of quality in the laboratory. The first of these is observation of the degree of lignification of the fibre by the phloroglucinol test; the best samples do not give any reaction with phloroglucinol, but the lower qualities give a reddish-brown or even a magenta-red colouration, typical of lignocelluloses. The second test consists in the microscopical measurement of the diameters of the fibres; the more uniform the diameter, the higher is the quality of the material. The third test is carried out by floating the fibre on the surface of aqueous alcohol, of sp. gr. 0·928, and determining the relative rates of wetting and sinking of the different samples.

Particulars are given of the flotation and resistance to submersion of certain appliances made with kapok. The life-saving jacket tested contained 700 grams of kapok, and, since the average floating power of the compressed fibre is equal to fifteen times its weight, the jacket, when submerged, exerts a lifting power of 10·5 kilograms. When placed in water and partially submerged by a weight of 9 kilos, the jacket still supported an extra load of 1·3 kilos after seventy-two hours; after one hundred hours it still required an addition of 1·0 kilo to submerge it, and after 192 hours the weight required was 0·9 kilo.

NOTES ON BOOKS.

Sir William Ramsay, K.C.B., F.R.S. By Sir William A. Tilden, F.R.S. London: Macmillan & Co., Ltd. 10*s.* net.

No one who cares for competent biography, and is interested in the development of science and the methods of scientific research, can afford to neglect Sir William Tilden's admirable memorials of a life of high scientific aspiration and notable scientific achievement.

From childhood to death William Ramsay's life was uniformly happy and successful. By his own wish he was engaged from early youth in congenial scientific pursuits; he had neither poverty nor ill-health to contend with; no family troubles nor enemies, public or private, to distract his mind; and his biographer cannot so much as hint at any storm and stress periods such as often punctuate some of the most humanly interesting lives. For Ramsay, however, ample excitement was provided by his experiments and discoveries, and he was never daunted by difficulties of apparatus or material, although much of his most fruitful research was of necessity carried on in minute spaces and with minute quantities of gas, and involved not only the most skilled manipulation, but minute and laborious sifting of numerical results.

It is not given to many chemists to discover a new element; and we imagine Ramsay's most thrilling moment must have come to him when he was forty-two years old, with his triumphant isolation of a new constituent of our atmosphere. "The last twenty years of the nineteenth century,"

writes Sir William Tilden, "witnessed two discoveries in physical science, namely, the observation of X-rays and the isolation of the argon series of gases, which equal, if they do not surpass, in significance and interest the discoveries of any previous period. Of the two, the latter must be regarded as the most surprising, because it was not only unexpected, but the existing evidence appeared conclusive against the possibility of such a discovery." Of the important part played therein by Lord Rayleigh, and the preliminary investigations regarding the atmospheric gases which led eventually in 1894—an unlucky but obvious misprint gives the year as 1914—to the isolation of argon by Ramsay, and his later discoveries of helium, neon, krypton, and xenon, his biographer gives a careful, historical, and scientific account, adequately documented; while an interesting appendix describes, with diagrams, the apparatus used by Rayleigh and Ramsay for isolating argon in bulk from the air. Ramsay's work on radium, into which he threw himself with characteristic zest after the isolation of radium salts by Madame Curie in 1902; the researches which occupied his later years; his activities in connection with the Chemical Society, the Society of Chemical Industry, and the British Association, are of course all sufficiently dealt with. A chapter is devoted to his well-known and pronounced views on education and competitive examinations, which are presented without bias by one who is, however, obviously of a less dogmatic and more conciliatory spirit in these matters; while other aspects of a life and character completely unspoilt by success and fame—Ramsay's friendships, his popularity with his students, his travels, his gaiety of spirit, and his practical benevolence—are all indicated with sympathetic and appreciative understanding.

Ramsay was at the least a singularly happy example of one of his firmest educational convictions, that the good teacher must also be at the same time a learner—which means in physical science an investigator. From 1874, when he was appointed assistant to Professor Ferguson of Glasgow University, till 1912, when (four years before his death) he retired from the chair of Chemistry at University College, London, which he had occupied for a quarter of a century, he successfully combined the arduous duties of the teaching profession with his own independent researches. All his students can testify to the result.

Joseph Pennell's Pictures of War Work in America. Philadephia and London: J. B. Lippincott Company. 9*s*. net.

Some eighteen months ago the *Journal* contained a review of Mr. Pennell's "Pictures of War Work in England." Since then the artist, who believes that "the place for an American at the present time is home," has transferred his headquarters from London to New York, and he has busied himself in carrying on in America the remarkable series of drawings which he started in this country.

For the ordinary reader on this side of the Atlantic the interest of the book is twofold: the drawings are an artistic feast, and they give a comforting sense of the energy which our Allies are throwing into the gigantic task of providing munitions of war. The subjects are taken principally from ship-building yards, gun-pits and shell factories; and they afford Mr. Pennell opportunities for those tremendous effects of light and shade in which he specially delights.

The thirty-six lithographs which the book contains are all admirable, though they attract in different ways: some, such as the armour-plate press, the gun-pit, and the "biggest hammer in the world," by their bold contrasts of black and white; some, such as the transports and the building of destroyers, by their delicate drawing. The riveters' workshop is curiously suggestive of a cathedral. One of the most striking sketches is that of the locomotive shop, in which a huge engine is seen suspended high in the air—the sheds in which the locomotives are constructed being too small to allow them to be moved about in any other way. Another remarkable drawing shows an American munition town, the houses of which can be put together in forty-five minutes!

Mr. Pennell comments on the fact that in America women have not to any extent gone into the factories, mills and shipyards of the country, and he hopes they never will. If the United States can turn out all the necessary munitions without calling upon their woman power, so much the better; and it will no doubt be pleasant for the Central Powers to know that we still have this immense resource practically untapped.

Forestry Work. By W. H. Whellens. London: T. Fisher Unwin, Ltd. 8*s*. 6*d*.

During the last thirty years we have had Forestry Commissions and Committees, ending recently with the Forestry Report of the Reconstruction Forestry Sub-Committee. Concurrently with these we have had only a comparatively small number of books published on the subject. Now we have the latest on this subject, dealing chiefly with all the various processes to be undertaken in connection with afforestation by a most practical forester. As there is a definite sequence in all the operations from the time of clearing the ground to the day of cutting the trees when they are financially ripe, so in this book a similar order is followed. In addition to "The First Steps towards Afforestation," "Raising the Plants," "Preparing the Ground for Transplants and Transplanting," we have separate chapters on "Preparing the Planting Area," as also "Stocking the Ground." "Impervious Pans," which are somewhat common in parts of England, have to be broken up before planting operations can profitably be undertaken. The "Raising of the Plants" may be done in the "Home Nurseries," or in "The Temporary Forest

Nursery." Later on we come to "The Tending of the Plantations," as well as "Clearing of the Crop." Again, there are "Insect and Fungoid Enemies," coming unasked for, but which have to be combated. "Measuring the Ground" is another process requiring care. In the 236 pages of this book all these subjects are dealt with fully, and all the processes accurately described. During the last few years we have had quite a number of books dealing with forestry, but none so fully going into all the proprietary work of afforestation. Although this work is chiefly meant for woodmen and foresters, it should be of the greatest use to consulting foresters, forest officers, estate agents, and all lovers of the forest. The results of other most complicated experiments are mentioned here, such as the most profitable "rotation" under which it is best to grow trees. In other words, after how many years can trees which have been planted in a wood be cut down? For instance, 120 to 150 years elapse in the case of oak, 90 to 100 years in the case of ash or sycamore, while a period of 70 to 80 years is usually sufficient for Scots pine, larch, or Douglas fir. "Nursery Notes" and "Beating Up" of plantations are each treated separately. Towards the end of the book there are 40 tables of measurements of length or area, such as inch, link, foot, yard, pole, chain, furlong, and mile, besides square chain, rood, or acre. The notes on fencing, draining, number of plants per acre, are most complete. The timber weights, as well as the notes on the technical properties of wood, are most useful. The writer of the work found difficulty in obtaining such data, so that what he mentions are the results of careful observations extending over a number of years, and all are based on his practical experience.

A. H. UNWIN.

GENERAL NOTES.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.—The British Science Guild, with the assent of the Ministry of Munitions and the approval of the Board of Trade, is arranging for an exhibition, to be held at King's College, Strand, London, from August 12th to September 7th, of products and appliances of scientific and industrial interest which, prior to the war, were obtained chiefly from enemy countries, but are now produced in the United Kingdom. The chief purpose of the exhibition is to make clear the necessity of scientific research with respect to the application of its results in the arts and industries; and, further, to display to the public and to those intimately concerned how much has been successfully achieved in this regard since the advent of the war in the production of articles of prime importance, not only for the home but also for foreign markets, hitherto manufactured in or imported from other countries.

THE CHANNEL FERRY.—This project, laid aside some years ago, is to be revived, according to the paper recently published by the British Chambers of Commerce in Paris, by Sir John Pilter and M. de Cordemoy. We take the project to mean, not a supersession of the tunnel scheme, which alone, for many of its advocates, seems necessary, but an adjunct as well, and in the meanwhile, during the construction of the tunnel, a temporary provision. The paper implied a scheme of steam ferries of 25,000 tons gross accommodation, twice a day, 300 ten-ton waggons, two decks above waterline. In the session of 1905, a proposal was made and subsequently withdrawn, the particulars of which the present writer was enabled, through the courtesy of Lord Weardale, the Chairman of the Channel Ferry Co., to give in the engineering press of the time. The ferry boats at that period were designed by the late Sir William White and Sir W. Armstrong, Whitworth and Co., who had much experience in the design of American lake ferry steamers, etc.

ECONOMY OF COAL.—In his presidential address to the Society of British Gas Industries, Sir Robert Hadfield, F.R.S., gave some information he had been able to obtain regarding a discussion on coal and fuel consumption which took place in November last at a meeting of the Verein Deutscher Ingenieure at Charlottenburg. Professor Brabbee, on the occasion referred to, pointed out that Germany, at the present rate of extraction of coal, would probably have sufficient for another thousand years, England 600 years, and France 500 years, but Germany possessed only about 15,000 square kilometres out of the, roughly, 550,000 square kilometres of coalfield of the earth, while the Union and China possessed 200,000 square kilometres each. Dr. Brabbee dwelt upon the advantage of the central heating system as compared with isolated heating, and showed that many so-called coal economisers were quite worthless. He calculated that, with strict observance of all principles at present recognised as correct, at least 25 per cent.—that is, about 8,000,000 tons of coal—would be saved annually in domestic consumption of fuel, corresponding to an average value of, say, £6,000,000. Turning to America, Dr. David Moffat Myers had pointed out that in one steel-mill which he had investigated there was a waste going on of no less than 40,000 tons per year. This, at a value of £1 per ton, meant £40,000, and yet the plant was a comparatively modern one. Sir Robert Hadfield expressed the hope that our new Fuel Research Board will examine this question with the idea of avoiding the serious waste which unfortunately exists in this country as in America. "Whilst there may be two plans of operation worthy of consideration, the autocratic and educational, surely," he said, "the latter, in which patriotism and efficiency furnish the motive force, would be the best to follow."

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

Journal of the Royal Society of Arts.

No. 3,429. VOL. LXVI.

FRIDAY, AUGUST 9, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE ECONOMIC CONDITION OF THE UNITED KINGDOM AFTER THREE AND A HALF YEARS OF WAR.

By Edgar Crammond,

Late Secretary of the Liverpool Stock Exchange; Managing Director of B.S.T. Limited.

Lecture II. (*concluded*).—*Delivered February 25th*, 1918.

The war has brought home to the people of the United Kingdom the fact that British sea power depends almost as much upon the mercantile marine as it does upon the Royal Navy. allied countries; 14 per cent. had been occupied in carrying foodstuffs and raw materials on behalf of the Government and the Allies, and the remaining 43 per cent. had been left to British shipowners under State regulations as to its use. The assistance we were rendering to our Allies in respect of shipping was on a scale unprecedented in any war. Out of a total of between 3,000 and 4,000 British ocean-going steamers we had dedicated over 500 to the exclusive service of France, Italy, and Russia.

It is noteworthy that, in spite of these vast calls, our mercantile marine was able to fulfil in a very complete manner its vital functions in the carriage of foodstuffs and raw materials in the first year of the war, as is shown in the following table:—

Imports.

	Peace conditions. Year to July 31st, 1914. Tons.	War conditions. Year to July 31st, 1916. Tons.
Food, drink and tobacco	16,100,653	15,579,574
Raw materials and articles mainly manufactured	26,376,656	22,500,576
Articles wholly or mainly manufactured	6,452,185	3,537,603
Articles for which weights are not given—estimated weight	6,672,000	5,674,608
Totals	55,601,494	47,292,361

A report issued by the Mercantile Marine Service Association in December, 1917, showed that 76,000 officers and men were serving in the Royal Naval Service and about 33,000 officers and men in the Royal Naval Volunteers, while more than 8,000 seamen had been drowned or killed, and that 4,000 others were prisoners. Lord Beresford stated on May 3rd, 1916, that we started the war with 11,353 vessels of over 400 tons. The Admiralty requirements were between 2,000 and 3,000 vessels. That left about 8,300 vessels to carry on the trade of the country at that time. Earl Curzon said on the same date that over 43 per cent. of British shipping had been requisitioned for the naval and military and essential civil needs of the

Throughout the first twelve months the tonnage entrances and clearances diminished by 29·8 per cent., but the weight of the cargoes carried decreased by only 12·7 per cent.

The fact that the ships remaining were able to carry the trade is accounted for in several ways. First, a number of the vessels taken up by the Government were passenger ships which were not, in times of peace, large cargo carriers; secondly, the steerage accommodation on a number of emigrant ships was taken out and the space used for carrying cargo; thirdly, the ships carrying the cargo have been more fully loaded.

"During the first eighteen months of the war, from August, 1914, to February, 1916, the nation depended in the main for its overseas

supplies on the enterprise and exertions of the individual traders and shipowners, and its supplies of all essentials were maintained, although from one-fifth to one-fourth of the ocean-going ships had to be devoted to war services. During the next twelve months, from February, 1916, to February, 1917, the employment of ships was limited to voyages approved by the Government, but the management of the ships on such voyages was left in the hands of the shipowners, and the cargoes carried on these voyages were in the main provided by the traders; and, again, the nation's supplies of all essentials were maintained, although more of the carrying ships had had to be devoted to war services and material help had to be given our Allies."* The reduction by nearly one-half of the mercantile tonnage available for the sea commerce of the world naturally exercised a profound influence upon freights, and *Fairplay* for December 21st, 1916, contained a diagram which showed that outward freights in 1916 were 614 per cent. and homeward freights 570 per cent. of those in force in 1900, but this does not mean that the aggregate earnings of British shipping in 1916 were six times as great as those received in 1900, as throughout 1916 about 55 per cent. of the tonnage was run on Blue Book rates, 20 per cent. on directed rates, and only 25 per cent. at the current market rates. From a careful examination of all the available data, I have arrived at the conclusion that the following is a fair estimate of gross earnings, working expenses, and net profits of our shipping industry for the year 1916:—

"On its formation (in December, 1916) the present Government determined to requisition all British ocean-going steamships, and it did so for the purpose of securing the whole of the profits to be made from the freights over and above the Blue Book rates paid on a time basis for the use of the ships. The terms offered were (1) that the shipowner should be paid for the hire of his ship rates which had been fixed in 1914, and which, according to the Chancellor of the Exchequer, were, by reason of the great increase in operating charges, then below the pre-war rates of earnings; (2) that all established steamship lines should maintain at home and abroad their organisations, being reimbursed the actual net cost of maintaining the same; (3) that with such organisations the established lines should run for the profit of the State their own and any other vessels entrusted to their care; and (4) that in the event of a vessel being lost through a war peril, the shipowners should receive by way of compensation a sum which represents on the average about two-thirds of the cost of replacement." *

I estimate that the gross freights earned by the British mercantile marine, all of which was practically worked on Government account, in 1917 amounted to about £480 millions.

Early in 1917 the Government adopted a policy of building standard cargo ships in private yards, the vessels being the property of the State and being run by the shipowners' organizations on behalf of the State. At the same time the War Cabinet decided to establish, as a means of increasing the shipbuilding resources

BRITISH SHIPPING—ESTIMATED GROSS EARNINGS.†

		Year 1916.
Gross earnings—		
11,000,000 tons at Blue Book rates, say, an average of £9 per ton. . . .	£99,000,000	
4,000,000 tons partly under directed rates, *i.e.* carriage of sugar, meat, wheat, iron ore, etc., say, an average of £22 per ton	88,000,000	
5,000,000 tons free, *i.e.* at current market rates, say, an average of £36 per ton	180,000,000	
	————	£367,000,000
Working expenses—		
Coal	£41,000,000	
Wages	30,000,000	
Provisions, stores, etc.	15,000,000	
Repairs	15,000,000	
Insurance	45,000,000	
Dock dues, light dues, Suez Canal	18,000,000	
Miscellaneous, including administration and ordinary depreciation . .	15,000,000	
	————	179,000,000
Gross profit		£188,000,000
Excess profits duty		£84,000,000
Income tax		24,000,000
Extra depreciation, renewals, reserves, etc.		50,000,000
Interest and dividends on capital and reserves		30,000,000
Total capital and reserves employed		300,000,000
Average dividend, say, 10 per cent.		

* Annual Report of the Liverpool Steam Ship Owners' Association for the year 1917.

† "The British Shipping Industry," by Edgar Crammond.

of the country, four national shipyards, with accommodation for thirty-two ships.

The second great phase of the war, so far as the mercantile marine was concerned, dated from February, 1917, when Germany began her intensive submarine campaign. The official returns show that from February, 1917, to the end of January, 1918, 827 ships of 1,600 tons gross and over and 302 ships of less than 1,600 tons gross had been sunk. The *Times* of January 5th, 1918, contained the following message from its New York correspondent, dated New York, January 4th :—

"Mr. Grasty, in a message from London to the *New York Times*, gives the following shipping figures, which, he says, have been obtained from a reliable source :—

	Total tonnage.
British ships over 1,000 tons, August, 1914	16,841,519
Loss by enemy action and otherwise, less new construction, purchase and captures . . .	2,750,000
Ships remaining, January 1st, 1918	14,091,519

These important figures, the message says, tell accurately the story of the results of the submarine campaign against British shipping.

"In a statement issued to the press and published in the *Times* on August 4th last, it was pointed out that the ocean-going tonnage on the Register of the United Kingdom, inclusive of prizes, was a little over 15,000,000 tons, of which 14,000,000 tons were employed in home service. Of the 14,000,000 tons thus employed, only about one-half was available for the trade of the country. About 6,500,000 tons were allocated entirely to the needs of the Navy, the Army, our Allies, and the Dominions overseas. A further million tons, or thereabouts, were being used for these purposes for the outward voyage, and were therefore lost to our export trade, but were available for imports."

Sir Eric Geddes, speaking in the House of Commons on December 30th, 1917, said : "The actual tonnage of war vessels and merchant vessels combined which we have finished in 1917 will equal the output for the record year 1913, in which year the equivalent of 2,280,000 tons gross of warships and merchant vessels was launched, viz., 1,920,000 tons of merchant shipping and 362,000 tons gross of war vessels.

The total gross tonnage of the British mercantile marine appears to have declined from nearly 21 million tons in July, 1914, to between 17 and 18 million tons gross at the end of 1917.* On November 1st, 1917, Sir Eric Geddes informed the House: "Our present position in merchant shipping is an interesting phenomenon of the war. The fact shows how quickly our surplus resources can be wasted, and we can take courage in remembering that at the same time we have grown strong where we were weak. Some never thought it was possible in the early months of the war to help the great host of our Allies in France and the other theatres of war, but they are now equipped on a scale never dreamt of before. This effort was achieved in part at the cost of our mercantile marine, and also in part at the cost of our Navy. If we had continued during the war with our merchant shipbuilding on its pre-war level, we should have been between two and three million tons to the good, but expenditure of effort in one direction calls for reconstruction in another, and we were fortunate that we started well supplied. The House will recollect that even so, we are less than 2½ million tons down on the register of big ships. Might the country not justly take courage from the fact that in 1917, with our munitions effort at the maximum and with a call upon our man-power which reduced our available resources to the minimum, we shall have produced naval and mercantile tonnage to an extent almost equal to the best year ever recorded in our history, and in 1918 it will certainly be very much greater?"

The gross tonnage of merchant shipping launched in the United Kingdom during each of the past five years was as follows :—

	Tons.
1913	2,127,000
1914	1,728,000
1915	650,919
1916	541,552
1917	1,163,474

The position of British shipping and the maintenance of our foreign trade during the war naturally exercised a profound influence upon the economic life of the people. At the outbreak of hostilities, the insurance market was paralysed for a short time. Before the crisis became acute, the war risk was nominal,

* The Official Return issued March, 1918, showed that the losses through enemy action and marine risks from the outbreak of war to the end of 1917 were :—

		Gross tons.
		7,079,492
Output of merchant shipbuilding in United Kingdom . . tons gross	3,031,555	
Enemy tonnage captured ,, ,,	780,000	
		3,811,555
Net loss		3,267,937

but when the position began to look black it rose to 4 per cent.; immediately after the outbreak of war it was 10 guineas, and two days after the declaration it was 20 guineas per cent. Commerce could not adapt itself within a short period to such violent change, and for a few days shipping was disorganised and the foreign exchanges completely broke down. This naturally caused a great disturbance in our foreign trade. Immediately after the outbreak of war the imports fell heavily. The figures for August, 1914, were 24·3 per cent. less than in August, 1913. The decline continued until October, 1914, when it amounted to 28·1 per cent. In November there was a marked recovery, and from that month there was a steady and continuous rise in the value of the imports. This continued throughout the whole of 1915, 1916, and 1917. The effect of the war on export trade was much more serious. The falling off in August, 1914, amounted to 45·1 per cent., and this had only been reduced to a decrease of 39·3 per cent. in December; but from that date onwards there was a steady improvement, and by the end of May, 1915, values had reached the figure shown for 1913. The course of our foreign trade, month by month, over the whole of the war period and the growth of the excess of imports over exports are shown in the graph on page 597.

Over the whole of the war period—that is, from August, 1914, to December 31st, 1917—there was an excess of imports over exports amounting to £1,301 millions, or at the average rate of £372 millions per annum. For the year to December 31st, 1917, the excess of imports over exports was £461·4 millions. The average excess of imports over exports for the three years 1911 to 1913 was £134·3 millions. The excess of imports over exports during the war period was, however, considerably greater than appears from the Board of Trade figures, which down to June, 1917, did not include Government purchases abroad. No exact data have been published for calculating the volume of these purchases, but in the latter part of 1916 it was announced that the direct purchases by our Government in the United States amounted to about £12 millions a week. From July, 1917, onwards, the figures included, for the first time, all Government imports and exports so far as figures were available, except exports for the use of H.M. forces on active service. The figures relating to our foreign trade are certainly impressive. That notwithstanding the withdrawal of so many workers and the dislocation of our shipping and finance we should have been able to maintain our exports at such a high level is a magnificent tribute to the industry and resource of the British people.

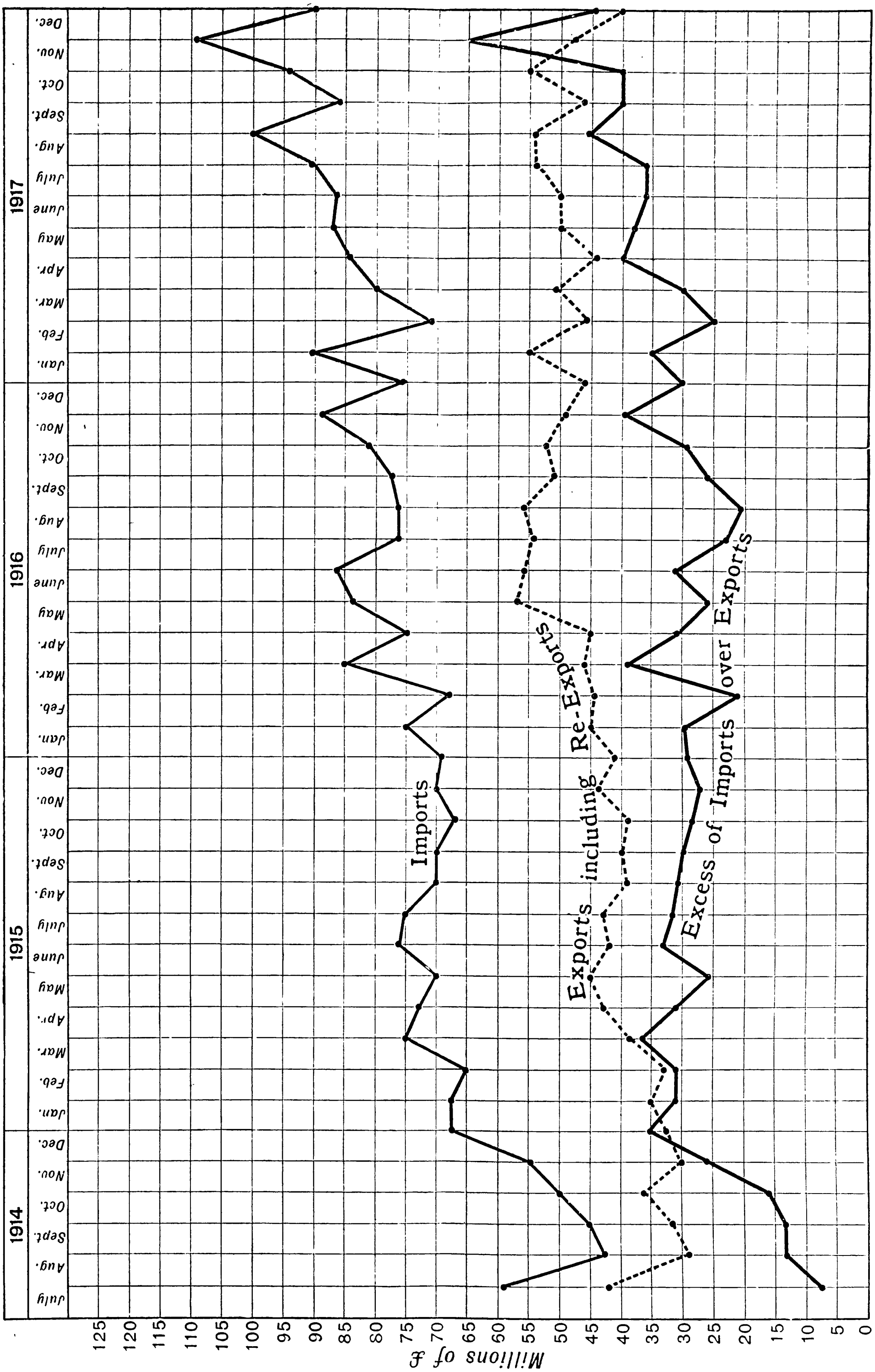
In considering the excess of imports over exports, it must be remembered that the Board of Trade returns do not disclose what are termed "invisible imports and exports." The exports are given "F.O.B.," that is to say, free on board; and the value of the imports are returned "C.I.F.," that is to say, cost, insurance, and freight. In other words, the official returns debit us with insurance and freight on imports and do not credit us with insurance and freight on exports. The freight and insurance now represent a much larger proportion of the total cost than they did in time of peace, when they were about 8 per cent. In addition to carrying two-thirds of our own sea-board trade and half the sea-board trade of the world, we also finance and insure considerably more than half the world's trade. The magnitude of our earnings from underwriting may be gathered from the fact that the premiums paid at Lloyd's in 1913 amounted to £12 millions, and in 1916 they reached £34 millions, while in 1917 they were considerably more (*Daily Telegraph*, December 11th, 1917).

In pre-war times, the marine companies' income would have been in the proportion of 6 to 4 as compared with Lloyd's, but it may be assumed that in 1916 the marine companies' income would not amount to more than Lloyd's. This would give total premiums of £30 millions in 1913 and about £68 millions in 1916, and for 1917 the total probably reached £90 to £100 millions.

In order to show the true state of our foreign trade balance, I have prepared the following estimates of the manner in which our trade balance was adjusted during each of the four years 1914–17:—

FOREIGN TRADE, 1914.

	£
Debit Items—	
Imports of Commodities . . .	697,400,000
Bullion and Specie—Gold . . .	58,642,000
Silver . .	11,953,000
Loans to Allies and Dominions .	40,000,000
Imports on Government A/c. . .	100,000,000
	£907,995,000
Credit Items—	£
Exports of Manufactures . . .	430,200,000
Re-exports	95,500,000
Exports, Bullion and Specie—Gold	30,599,000
Silver	10,889,000
Interest on Investments abroad .	200,000,000
Earnings of Shipping, Banking Insurance, etc.	140,000,000
	£907,188,000


1914
1915
1916
1917
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
Imports
Exports including Re-Exports
Excess of Imports over Exports
Millions of £
125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0

FOREIGN TRADE, 1915.

	£
Debit Items—	
Imports of Commodities	851,900,000
Bullion and Specie—Gold	10,828,000
Silver	10,560,000
Loans to Allies and Dominions, and Investments in French, Russian and Italian Bonds.	240,000,000
Imports on Government A/c.	200,000,000
	£1,313,288,000

	£
Credit Items—	
Exports of Manufactures	384,900,000
Re-exports	99,100,000
Exports, Bullion and Specie—	
Gold	39,218,000
Silver	7,360,000
Interest on Investments	180,000,000
Earnings of Shipping, etc.	200,000,000
Banking Insurance	60,000,000
Sale of Foreign Investments	250,000,000
Moneys borrowed abroad	100,000,000
	£1,320,578,000

FOREIGN TRADE, 1916.

	£
Debit Items—	
Imports of Commodities	949,200,000
Bullion and Specie—Gold	17,790,000
Silver	13,677,000
Loans to Allies and Dominions	540,000,000
Imports on Government A/c.	250,000,000
	£1,770,667,000

	£
Credit Items—	
Exports of Manufactures	506,500,000
Re-exports	97,600,000
Exports, Bullion and Specie—	
Gold	38,449,000
Silver	10,741,000
Interest on Investments	170,000,000
Earnings of Shipping, etc.	300,000,000
Banking Insurance, etc., say	50,000,000
Sale of Investments and Moneys borrowed abroad	600,000,000
	£1,773,290,000

FOREIGN TRADE, 1917.

	£
Debit Items—	
Imports of Commodities	1,065,256,000
Loans to Allies and Dominions	600,000,000
Imports on Government A/c.	600,000,000
	£2,265,256,000

	£
Credit Items—	
Exports of U.K. Produce and Manufactures	525,309,000
Re-exports	69,552,000
Interest on Investments	150,000,000
Earnings of Shipping, etc.	480,000,000
Banking Insurance	160,000,000
Sale of Investments and Moneys borrowed abroad	900,000,000
	£2,284,861,000

The figures are not strictly comparable because there was a change in the statistical method of dealing with publicly-owned goods, the complete figures for which have been included in the second half of 1917, while most Government goods except food were included in the first half of the year. During the whole period, 1914 to 1917, the value of our imports, as shown by the Board of Trade figures, exceeded that of our exports by £1,383,500,000; but, as already explained, this amount can be largely accounted for by freights and insurance charges which were ultimately received by this country. We made new loans to the Dominions and to our Allies during the war period amounting to approximately £1,500 millions, and, on the other hand, we borrowed moneys abroad or sold part of our investments abroad amounting together to about £1,900 millions.

Owing to the abnormally heavy adverse trade balance, the maintenance of the foreign exchanges, which was an object of the first importance for the finance of the war, was a matter of great difficulty. Towards the end of July, 1915, the American Exchange became increasingly unfavourable. Immediately after the outbreak of war it had been as high in our favour as 6, and as the normal gold parity is 4·8665 this represented a premium of 20 per cent. By April, 1915, it had fallen back to 4·86, and a slow but steady decline set in. On October 1st, 1915, the New York cable rate on London went as low as 4·50. This was primarily due to the exceedingly heavy payments which had to be made in New York for the British and Allied Governments. An Anglo-French Commission was then sent to New York and arranged for an Anglo-French loan of $500 millions. This measure did not prove adequate, and in December the Treasury announced that, with a view to facilitating the maintenance of the exchanges, the Treasury were prepared to purchase certain American and Canadian dollar securities owned in Great Britain, or to receive such securities on deposit. In the case of securities deposited on loan the lender was to receive all interest on dividends, and also by way of consideration for the loan an additional payment at the rate of half of 1 per cent. The scheme was subsequently extended to certain Japanese, Scandinavian and Argentine securities. These measures sufficed to maintain the exchanges throughout 1915, but not without wild fluctuations. In 1916 the movements were not so wide, and on the whole they were rather more favourable to this country, but owing to the increasingly heavy purchases abroad and loans to our Allies they gave further anxiety in the early part of 1917, and until America entered the war our position was unsatisfactory.

On October 31st, 1917, the Chancellor of the Exchequer stated in the House of Commons that "it was an open secret that before America had come into the war the method of financing our expenditure there and the question of exchange was not only a serious problem, but, so far as I was able to judge, it was an absolutely insoluble problem on any of the principles on which our finance had hitherto been carried on."

Owing to the financial arrangements which we were able to make with the United States Government the American exchange has been established on a satisfactory basis, but the neutral exchanges have moved against us. At the present time the sterling exchange, as measured in Swedish currency, has fallen about 23 per cent., and our exchange has been at a discount of 20 per cent. in Norway, 16 per cent. in Denmark, 9·5 per cent. in Holland, and 22 per cent. in Spain.

For the great majority of the people of the United Kingdom the outstanding financial feature of the war has been the rise in the cost of living. From the South African war down to 1905 wholesale prices showed comparatively trifling changes, and they fluctuated between 96 and 100, but in 1906 an upward movement began which continued almost without interruption until 1913. For the first half of 1914 there was a slight check to this advance. Immediately after the outbreak of war there was a considerable rise in the price of foodstuffs, but for the first five months the movement in raw materials was mainly downwards owing to the dislocation of trade. In 1915, however, practically every article advanced in a marked degree, especially in the later months of that year, when the abnormal freight situation was the dominant factor. The Board of Trade index number for forty-seven articles was 143·9 for 1915 as compared with 113·6 for January–July, 1914. The advanced continued throughout 1916, and was more pronounced than in the preceding twelve months, the index number for the year being 186·5. The upward movement continued at an accelerated rate in 1917, the index number for that year being 242·9. The advances in the prices of foodstuffs and raw materials since 1913 have been fairly approximate, although they have not been equal. The *Statist* index number shows that whereas in 1917 materials were 98 per cent. dearer, foodstuffs had risen 118 per cent.

There had been a widespread controversy as to the cause of the rise in prices and the effect of what is termed the inflation of the currency upon the course of prices. Professor Nicholson defines inflation to mean "an abnormal increase in the currency," and his conclusion is that "if the inflation of the currency continues the rise of prices will also continue."

The Select Committee on National Expenditure expressed the view that the chief causes of the increase in prices are :—

The expansion of credits during the war;

The demand for commodities exceeding the supply, and the inadequacy of Government action to control prices;

Increases of wages and consequent increases in the cost of production;

Increases in the rates of profit;

Unfavourable rates of exchange in some countries from which supplies are imported.

Some of these are at once effects of the increase of prices and causes of further increases.

The committee express the opinion that in the expansion of credit the issue of paper currency as hitherto practised in this country during the war plays a very subordinate part. If in any degree contractors' accounts had been met, or if the soldiers and sailors had been paid, simply by using the printing-press and issuing fresh supplies of currency for such purposes, the effect would, of course, have been serious. But this has not been done, and is not in contemplation. Notes are not issued in order to make Government payments. They are issued to meet requests from the banks for the currency needed by their customers; their quantity is regulated by those requests, and neither exceeds nor falls short of them; they have to be paid for by the banks by transfer of securities or in other ways. The amount of legal tender currency has largely increased. At the outbreak of war it is estimated that there was in circulation or in bank reserves about £222 millions. It is now calculated at about £338 millions, not including such small quantities of gold as may remain in the hands of the public. It is held, however, by the Treasury, that this increase is necessary in order to keep pace with the growth of transactions as measured in terms of money, and that it is a consequence and not a cause of the increased purchasing power of the community.

The Committee of the British Association on Credit and Currency issued a report in 1916 which contained an estimate founded on Mint returns of the pre-war amount of gold in the United Kingdom. The estimated amount at the end of June, 1914, was £161·1 millions, of which £82·8 millions were held by the banks

and £78·3 millions by the public. In effect, the gold formerly in the hands of the public has been withdrawn from circulation and its place has been taken by the currency notes. The total amount of the latter outstanding at the end of January, 1918, was £212 millions.

I am strongly of opinion that the rise in prices cannot be fairly ascribed to what is termed the "inflation of the currency." The advance is, I believe, entirely attributable to the war, which, on the one hand, produced intensification of demand, and on the other hand, an obstruction of supplies. This, coupled with the necessity of changing the character of the national production from a peace basis to a war basis, appears to me to entirely account for the rise in prices. As the prices of commodities advanced the amount of the circulating medium required to finance the trade of the country had to be increased to a corresponding extent. The rise in wholesale prices has amounted to 128 per cent., and the quantity of production has been well maintained, even if it has not been increased, and that we should have been able to finance such a gigantic war with an increase of currency of only 52 per cent. appears to me to be a magnificent tribute to the soundness of our financial and monetary systems. It is instructive to note that while our currency has increased by £116 millions, or 52·2 per cent. during the war, the paper money in circulation in the United States increased by £248 millions, or 46·4 per cent. In Germany the circulation of the notes of the Reichsbank increased from £94 millions to £573 millions at the end of 1917, an advance of £479 millions, or 509 per cent.

The belief appears to be generally entertained that the cost of living has increased by 105 per cent. since the outbreak of war, but Lord Rhondda stated (January 3rd, 1918) that the Board of Trade figures showing a rise of 105 per cent. were altogether misleading, for the cost had not gone up by very much more than 50 per cent., and during the last six months the actual cost had decreased by 10 per cent. People had had to alter their method of living, and were not consuming the same class of food. Lord Rhondda, however, omitted to state that the bulk of the decrease was due to the fact that the Government had allocated £45 millions for the purpose of reducing the price of the loaf to 9*d*.

It must be remembered that the increase in the cost of living is a world movement, and has not been by any means confined to belligerents. The *Labour Gazette* for August, 1917, and February, 1918, gave the following particulars as to the increased cost of living since August, 1914, in the countries referred to:—

1917.

Canada	(November) . .	63·1 per cent.
Switzerland . .	(March 1st) . .	57·3 ,,
Norway . . .	(March) . . .	82·0 ,,
Australia . . .	(February) . .	25·6 ,,
Italy	(end of April) .	63·9 ,,
United States . .	(October) . .	53·0 ,,
Sweden. . . .	(November) . .	99·6 ,,

The rise in prices and the consequent increase in the cost of living brought about a deep feeling of unrest throughout the country. It was believed that private interests were exploiting the needs of the populace, and that there was a vast amount of profiteering. Very exaggerated views appear to be entertained as to the extent to which profiteering has affected the rise in prices. At first it was said that the shipowners were the culprits, but on July 20th, 1917, Mr. Clynes (Ministry of Food) told the House of Commons that shipping rates had no important bearing on the cost of the principal articles of food. Later the farmers were accused of profiteering and holding up supplies, but no satisfactory evidence has yet been produced in support of this charge, and the public must ultimately recognise that one of the principal causes of the rise in the cost of food is the persistent demands of labour for increased wages. As the Select Committee on National Expenditure stated in their report: "Fresh cycles of wage advances succeed one another. Each one results in further increases of prices or in preventing a reduction of prices. An individual trade may obtain by a wage advance temporary relief from the increase in the cost of living, but only, as a rule, at the expense of all other trades. And the gain is short-lived, for the result is a demand from the others for similar advances, which raise the cost also of the commodities they produce. The producers are raising prices against themselves as consumers. Meantime the cost of the war is vastly increased. We are deeply impressed by the seriousness of the position in this respect, and are convinced that, if the process continues, the result can hardly fail to be disastrous to all classes of the nation."

After the outbreak of war employment became very acute, and before the end of 1914 a considerable amount of overtime was being worked, and in several trades complaint was being made of a shortage of labour. This was especially the case in engineering, shipbuilding, woollen, and

leather and kindred trades. Concurrently the prices of food and other necessaries rose. In the circumstances, the movement began in 1915 to raise wages. From March onwards it spread to nearly all the principal industries, and its effects have been far greater than those of any other upward movement in wages previously recorded. No complete account can be given of all the changes in rates of wages which have been made since the beginning of the war, as among the unorganised workers many changes escape attention, but it appears that up to the end of 1916 nearly six millions of workpeople received some advance. The average weekly increase was about 6*s.* per head. In 1917 a further great increase of wages took place, and 4,700,000 workpeople received advances of wages amounting in the aggregate to £2,200,000 per week (*Labour Gazette*, January, 1918).

On November 21st, 1917, Mr. Bonar Law stated that in the case of income tax assessed quarterly upon weekly wage-earners employed by way of manual labour, the following estimates might be given for the year 1916-17:—

Gross assessments	£202,000,000
Net produce	3,000,000
Number of wage-earners with incomes above exemption limit . .	1,500,000
Number of weekly wage-earners liable to pay tax after deduction of the statutory abatements and allowances	630,000

Taking the whole of the employed people of the United Kingdom, I estimate that the wages bill for 1917 was between £500 and £600 millions more than in 1913.

As a result of the pressure of public opinion, a Ministry of Food was created at the end of 1916. The duties of the Minister, according to the Act, are "to regulate the supply and consumption of food in such a manner as he thinks best for encouraging the production of food." The Ministry set itself to control all foodstuffs, with a view to making them accessible to the community in equitable shares and at reasonable prices, and to limit the profits derivable from all transactions and sales relating thereto, and to reduce the cost of necessaries as far as possible. It accordingly brought all the principal foodstuffs under control, as well as a number of subsidiary foods. The stupendous task of regulating the nation's food at a time of restricted supplies was naturally not accomplished without friction and difficulty. An important step in decentralisation was taken in the appointment of local food committees with considerable powers over prices and distribution, and there are now about 2,000 of these committees at work.

In the autumn of 1917 the campaign for voluntary rationing was inaugurated, but it did not meet with any great measure of success. The food position became somewhat acute at the beginning of 1918, when the meat shortage was severely felt and there was a great scarcity of butter, and by the middle of February a compulsory system of rationing was well on the way. On the whole, however, it may be fairly claimed that during the first three and a half years of war the great bulk of the people of the United Kingdom were as well, if not better, fed than in time of peace, and they were certainly better off in the matter of food than any of the other belligerents, with the exception of the United States.

I have now completed my rough survey of the manner in which the resources of Great Britain have been organised for war, and I hope, notwithstanding its incompleteness, it is an impressive picture. A number of people are so busily engaged in finding fault with matters of detail that they have failed to envisage the national achievement as a whole. It is true that many ludicrous and sometimes tragic mistakes have been made. We had to find, by bitter and costly experience, the directions in which our strength could best be developed; but it is now possible to perceive that under the driving force of public opinion, and in accordance with that capacity for adaptation and improvisation which is one of our greatest national attributes, the task of mobilising all our resources for the purposes of the war has been accomplished with the utmost completeness and efficiency.

Happily, we started the war with an immense mercantile marine and a great and efficient navy. As history has proved time after time, sea-power is our real source of strength. It enabled us to put all the national effort into the building up of the Army and the Air Service. These tasks have been achieved at some sacrifice of sea-power, but we are now, in a measure, free to devote ourselves to the building up of our mercantile marine, and there can be no doubt that this will be done with true British thoroughness.

Great as has been our achievement in the past three and a half years, a wider and even more difficult task awaits us in the immediate future; but the splendid patriotism and the power of organisation of the British people as a whole inspire the confident belief that we

shall overcome the difficulties of demobilisation, and reorganise our industrial life in as complete and efficient manner as we have organised for war.

POWER FROM VOLCANIC STEAM.

In the barren, desolate region in the vicinity of Volterra, in south-western Tuscany, are a great many fissures or cracks in the earth's surface, from which small clouds of steam arise, evidently of subterranean origin. Almost a century ago a Frenchman, François de Larderel, visited this region and made an analysis of the steam. He discovered that it was heavily charged with boracic acid. Beginning at the Poggio Casa la Serra, extending south over the summit and down the valley of the River Cornia, he found numerous fissures from which steam arose. Selecting the largest of these, at what is now the town of Larderello, about fifteen miles due south of Volterra, he established a plant for the extraction of boracic acid, which was the beginning of what is now a most successful industry.

In the present plant the vents are covered, the steam condensed by the air as it reaches the surface, and the resulting water is led in open wooden troughs into shallow pans, where, by the aid of certain precipitates and evaporation, boracic acid in crystalline form is obtained. These pans, lined with lead, about 6 ft. by 4 ft. and 4 in. deep, are in sets, and arranged in steps on the slopes of the hill, so that the water, delivered by troughs into the highest pan of each set, drains through each pan of the series, and finally into a tank or vat. As evaporation proceeds, crystals of boracic acid are deposited along the edges of each pan, the edges being flattened and sloped so as to facilitate this process, from which they are gathered and taken to drying rooms and spread out on shelves to hasten drying. Both evaporation and drying have been assisted by the installation of pipes, much in the manner of steam-heating pipes, the steam used being obtained from the earth fissures. Steam from the same source is used to heat the offices of the company and the houses of the employees.

Several years ago, writes the United States Consul at Florence, it was decided to use some of the surplus steam from the fissures to operate a small horizontal engine. This was installed and used to furnish the small amount of power required for various purposes in the works, and is still used as occasion demands.

When the low-pressure steam turbine was invented, it was seen that it might be possible to use this steam as a source of power. Vents were selected, borings made, and it was found that no diminution of pressure resulted when the borings were made a sufficient distance apart, about 50 ft. to 100 ft. Holes were then made to a point where a pressure of from two to three atmospheres and a temperature of from 150° to 190° C. could be obtained from the steam. The power thus obtained was utilised for the production of electric energy, which could be transmitted to neighbouring towns. Additional capital was invested and a modern electric plant erected. Piped borings were made into the earth, from which the steam is carried to tubular boilers. As the steam is highly impregnated with boracic acid, the tubes are of aluminium outside. The steam is applied to these tubes, and the heat from it used to turn pure water, obtained from other sources, into steam, which, in its turn, operates the engines connected with the dynamos. There are installed at present three groups of alternating turbines of 4,000 h.p. each producing from the dynamos a three-phase, 50 period, 4,000 volt current. The current is transformed into 16,000 volts for transmission to Volterra, Saline di Volterra, Pomerance, Castelnuovo, and Monterotondo, all neighbouring towns. Current at the same voltage is delivered to the Società Maremma di Elettricita, which delivers it as far as Follonica, on the west coast. For the two large customers—the Società Elettrica Mineraria del Valdarno and the Società Ligure Toscana di Elettricita—the voltage is increased to 30,000 and 40,000, the direct line for the first going by way of Colle d'Elsa, above Sienna, and the Central of Castelnuovo, while that for the second goes by Cecina, on the west coast, and Castiglion Cello to the Central at Leghorn.

The company known as the Società Boracifera di Larderello has its offices in Florence, and is controlled there. On a capital of 5,645,000 lire, dividends at the rate of 5 per cent. per annum are paid. Apart from the power produced, it is stated that 2,537 tons of crude boracic acid, 839 tons of refined boracic acid, 1,164 tons of borax, and 55 tons of carbonate of ammonia, were produced in 1914. The steam is strongly impregnated with sulphur in one of its various forms, but this is eliminated when the steam reaches the open air.

SCIENTIFIC RESEARCH IN AGRICULTURE.

The President of the Board of Agriculture (Mr. R. E. Prothero), in the House of Commons on July 18th, reviewed the operations of his department during the past twelve months. After alluding to the work of Professor Russell at Rothamsted, in connection with the turning of grass land into arable, and the production of an effective soil insecticide, and of Professors Wood and Hopkins at Cambridge, on animal nutrition, he illustrated the possibilities of scientific research in agriculture from Professor Biffen's well-known plant-breeding investigations. He pointed out that, after examining a number of varieties of foreign wheat, Professor Biffen discovered a Russian wheat called ghirka, which resists rust. Now rust destroys annually thousands of quarters of wheat, but this ghirka wheat was of no use to the British farmer because its yield was miserably low. But Professor Biffen, by using the Mendel

system, was able to transfer the rust-resisting quality of ghirka to a high-yielding English wheat, and though that wheat has now been in use for several years, it has shown no tendency whatever to revert either to the rust tendency of one parent or the low-yielding tendency of the other. He has now produced a wheat which produces a high quality of straw—a fine, stiff, upstanding straw—and a high quality of yield of grain, so much so that without pushing it will produce forty-two bushels to the acre, and by pushing, up to seventy-two bushels to the acre. It also possesses a very high quality of disease resistance, which is so highly valued by both millers and bakers, and which is recognised in increased prices.

Mr. Prothero added: "Hitherto the plant-breeding work has been hardly applied to any of the crops of the farmer except wheat—though it has been applied partly to barley—and mainly to wheat suited to the Eastern Counties. But suppose you apply it to the wheats and barleys used in other districts, to oats and rye, to temporary grass and potatoes. There is an extraordinary list of possibilities opened to the British farmer. If, for instance, you could produce a potato which was immune from blight and immune from wart disease, it would be an invaluable boon to English agriculturists, and there is every prospect that that may be achieved."

THE INDIAN HIDE TRADE.

Sir Henry Ledgard, in the important paper he read before the Indian Section of the Society on February 14th, referred to the capture of this large trade by the Germans before the war. He declared that in the background there are still the old ring firms or their successors, resenting their present exclusion, agitating for recognition, bringing pressure to bear upon Government, trading with neutrals, "and ready to pounce upon the trade (of which they had the monopoly) directly peace is declared and the Continental market reopens."

In the House of Commons, on July 10th, Mr. Montagu, Secretary of State for India, said the statement that before the war the East India export trade in raw hides was largely in the hands of, and controlled by, the Calcutta Hide Trade Association, which worked with a Hamburg association, and by its methods virtually maintained a monopoly, was, he believed, substantially correct. The Calcutta Hide and Skin Shippers' Association consisted of seven firms, of which five had been wound up under the Enemy Trading Act, while from the remaining two enemy interests had been completely eliminated. He had ascertained from the Government of India that there three alien employees (two Swiss and one Italian) of liquidated firms had started business. The export trade in raw hides was now controlled by the Government of India, who, on behalf of his Majesty's and the Italian Governments, purchased the exportable surplus of certain classes. As purchasing agents five British or Indian firms were employed, but other firms, including the two reconstructed firms and the three new alien firms referred to, were permitted to participate in the export trade of hides not required by Government. They did not, however, in any sense enjoy a monopoly of such trade. The Government of India had the future regulation of this trade under consideration. The measures already adopted had done much to divert this trade to British and Indian merchants, and there was every reason to think that the enemy control of this important trade had been permanently eliminated. Asked if Mr. Howeson (late Ernsthausen) was not now occupied in getting back a considerable portion of this trade into German hands, Mr. Montagu said he could not carry in mind the details of the action of any particular individual, but he knew the Government of India were determined that any such efforts as suggested should not be successful.

NEW INDUSTRY IN GLASS-WOOL AND COTTON.

Spinning glass for commercial uses is an important new industry which has been developed in Venice within the past two years. The spun glass is marketed in three forms—hanks of spun glass thread of straight fibre called "Cotone di Vetro" (glass cotton), masses of spun glass curled fibre called "Lano di Vetro" (glass wool), and either of the above qualities pressed into sheets or pads from one-quarter to one-half inch in thickness that resemble white felt pads.

At present, writes the United States Consul at Venice, the principal use made of this product is for insulation, and especially for making separators for accumulators of electricity, but the glass wool would serve admirably for making artificial hair, wigs, perukes, doll's hair, Santa Claus beards, and other purposes, and in the pad form it serves as a hygienic filter.

The processes of manufacture are simple. Solid glass rods, about 2 ft. 6 in. long and the thickness of a lead pencil, are made of pure America soda that contains no adulteration of lead or other metal. The absence of lead and adulterations gives the quality of perfect flexibility to the fibre, and the best soda used in its manufacture comes from the United States, although an inferior kind was before the war obtained from France. On a simple desk is mounted a Bunsen burner or gas flame and blowpipe. By the side of the desk is mounted an ordinary bicycle wheel minus the rubber tyre, that revolves rapidly and regularly at rhythmic speed under power furnished by a small electric motor. A motor of 2½ h.p. will operate fifty or more wheels.

A girl sits at the desk, melts the end of the glass rod in the flame of the gas burner, draws it to a thread and throws the thread around the wheel. If the thread breaks, she must repeat the process; if not, she slowly revolves the end of the rod in the constant flame, and it is automatically spun to

a very thin filament. The hank of thread on the wheel, when it has assumed the dimensions of a bicycle tyre, is taken off. Separated with the fingers, it curls and fluffs out like wool if the thread is sufficiently fine. It is packed in the hank as glass cotton, in the fluff as glass wool, and in the compressed form as glass wool or cotton according to the fineness of the fibre.

The cheaper grades of spun glass formerly came from Germany. It is claimed that the Italian article is superior owing to the purer soda used.

ENGINEERING NOTES.

Concrete Chimney in Japan.—Particulars of a very high reinforced concrete chimney which has been completed in the last few months for a smelter plant at Saganoseki, Japan, are given in the *Engineering News-Record*. It is 570 ft. high, 42 ft. 8 in. outside diameter at the bottom, and 26 ft. 3 in. inside diameter at the top, with a thickness of 29½ in. at the bottom and 7 in. at the top. The design includes provision for earthquake stresses, and was checked and approved at the Imperial University of Tokyo. The foundation is a huge block of monolithic Japanese portland cement concrete, in the form of a truncated cone 17 ft. high, 95 ft. diameter on the base, and 42 ft. at the top. The centre portion of the top is concave, with a bottom thickness of 7 ft. This foundation contains 2,711 cubic yards of concrete, and required thirty days' work, day and night, for its construction. The pressure on the base is about 6,000 lb. per square foot, including allowance for wind pressure. The steel reinforcement in the foundation and chimney amounts to 530 tons, and consists of plain round and square bars of American make, purchased in Japan. The lightning-rod protection is quite extensive. At the top is a copper circle, with seven platinum points extending 4 ft. above the edge of the chimney. From this circle seven cables lead down the chimney. At a height of 400 ft. from the base is another copper circle, or circuit, with four platinum points, and from it four rods lead down to the base.

Rust Preventive.—A new rust-preventive remedy, recommended for small machinery parts, is, says *Ice and Cold Storage*, an application to the surface of the iron or steel of iron phosphates. After thoroughly steaming, the articles are immersed in a little bath containing ferric and ferrous phosphates, with a little manganese dioxide, and at boiling-water temperature they are left until hydrogen is no longer given off. The articles are then air-dried, when they may be treated with mineral oil, or painted, japanned, or otherwise finished. As the phosphate surface is attached chemically to the metal, no rust forms even in cracks in the paint.

Victorian Water Storage Schemes.—According to a statement issued by the Water Commission, says the *Indian and Eastern Engineer*, twenty-four sites have been inspected in the Upper Murray Valley for a suitable place to erect a large storage reservoir in connection with the Murray water scheme. The only site considered suitable is one about ten miles above Albury, just below the junction of the Mitta Mitta and Murray Rivers, and between the end of the Table Top Range in New South Wales and the end of the range between the Mitta and Kiewa valleys in Victoria. To provide storage here, holding 1,000,000 acre-feet of water, the barrage would be 4,000 ft. in length and 70 ft. in height above the level of the flats. Should the necessity arise at any future time to double the capacity of this proposed storage, the Water Commission states that it could be done by raising the barrage 30 ft.

South African Iron.—Dr. Wagner, in his presidential address to the mineralogical section of the South African Association for the Advancement of Science, announced that four small blast furnaces are being installed for the purpose of smelting the rich titaniferous iron ores of the bush veld, of which it is estimated 300,000,000,000 tons are available. Cheap Transvaal coal would be used, and Dr. Wagner stated that, if the experiment were successful, South Africa would eventually be able to export iron and steel, and to compete with the leading iron-producing countries.

Katanga Railway.—The recent completion of the section of this line to Bukama, says the *Railway Gazette*, on a navigable portion of the Upper Congo River, represents an important addition to the line between Cape Town and Cairo. There is the further promise, now that the Suez Canal has been bridged, of forging a rail between the African and Asiatic railway systems. The completion of this project would involve the construction of a large mileage of railways, and there is also the difficulty of break of gauge to be overcome.

Rhône Canal Scheme.—The importance of this scheme was the subject of a lecture delivered on behalf of the Nouvelle Société Helvétique at the Steinway Hall, by M. J. Valloton. He said that as soon as peace conditions are restored, the Germans will open the Rhine for commercial traffic, with the inevitable result of drawing Switzerland into the arms of Germany, and subjecting her to a complete economic servitude in the interest of Mittel-Europa, unless immediate steps are taken to counteract a tendency so harmful to the economic interest of the Allies, by making the Rhône navigable between Geneva and Lyons, thus giving Swiss commerce direct access to the Mediterranean. By this route Switzerland could obtain, besides coal, all the raw materials and colonial products which are necessary for her existence. All that is necessary is to make about twenty miles of the Rhône navigable by building

a lock at Genissiat, a work which, moreover, would put into use an hydraulic force of 300,000 h.p., capable of supplying Paris and the towns bordering on the Rhône with all the electricity which they could possibly use. The French Government has appointed a committee to go into the whole matter.

NOTES ON BOOKS.

THE MANUFACTURE OF INTERMEDIATE PRODUCTS FOR DYES. By John Cannell Cain, D.Sc. London, 1918: Macmillan & Co. 10*s*. net.

Modern dye materials, although there are exceptions, may be regarded broadly or generally as synthetic products, and, what is more, the synthetic dye-stuffs are, for the most part, end results of a long chain of intermediate stages, of which chain each link is a definite chemical compound. Thus it is that the synthetic dye industry has called into existence a new vista of organic compounds based on benzene as a more or less remote ancestor, these new organic compounds having been to a considerable extent called into existence in the quest for dye-stuffs. Incidentally, however, no small number of the intermediates thus called into existence, or their collaterals, have found valuable applications in other directions, as, for example, in photography and in medicine, and now possess definite importance in the world's work, quite apart from the dye industry.

Hence it is that the manufacture of the synthetic colours of our time is mainly and chiefly the manufacture of intermediate products; indeed, so much is this the case, that the colour manufacturer does not in all cases supply an actual finished colour, but instead he supplies intermediates, which are not dyes, but which the dyer so uses as to produce the required colours on the textiles or the yarns.

In this aspect of the case it may not be too much to say that Dr. Cain's book now before us is, in the fundamental sense, a much more real handbook of aniline colour manufacture than many in which the actual production of the colours is explained. The intermediates being in hand, the production of the colour is often an operation parallel in simplicity with Béroalde de Verville's mode of making slippers by cutting down a pair of boots.

In his book of 264 pages Dr. Cain deals satisfactorily with the three or four hundred intermediates which are essentials in the aniline colour industry, and in the really best sense of the term we may say he deals "fully" with this large number of products, as in addition to such particulars as it is practicable to include in the book, our author gives reference to every original source, although he expresses a doubt as to whether any single library in England contains the whole of the literature which is involved; but he has done his best to obviate the necessity of making reference to the original sources. This best is a very good best, and may be regarded to a considerable extent as an outcome of Dr. Cain's experience as editor of the *Journal of the Chemical Society*, there being nothing in the book which borders upon padding or "fill-up," and it is assumed that the reader has a good general knowledge of the chemistry of the aromatic series; hence the symbolic representations are not given in full, the benzene ring itself not being lettered. Further, there is no description of quite ordinary or everyday plant or appliances, but everything quite special to the operation is fully described and well illustrated. Again, the reader is often told to use the theoretical or equivalent quantity of a reagent. This conciseness detracts nothing from the real usefulness of the book, and enables the author to include far more than would otherwise be the case.

Dr. Cain can, however, be detailed, and even diffuse, where there is good reason for such a course, this being notably so in the section on aniline, pages 39–46. In this section aniline is not only aniline itself, but the typical amino-body of the aromatic series. Hence the student will find noted all those various modes of reduction of nitro-benzene which may have escaped the notice or knowledge of even mature chemists, who pride themselves on keeping thoroughly current. We may instance the reduction of the nitro-benzene by free hydrogen or by carbon-monoxide and steam, or by water gas, an appropriate catalyst being used in each case. For example, nitro-benzene vapour and hydrogen mixture reacts at 230° C. when poured over pumice coated with silver, or at from 230° to 250° when gold is the catalyst; but hydrogen and steam, if passed through nitro-benzene and then over finely-divided nickel, give an almost theoretical yield of aniline at low temperature.

The vacuum still for aniline is well detailed and illustrated.

So useful and thoroughly satisfactory a book will be alike welcome to manufacturer and student, and we may, perhaps, venture to predict a rapid growth in future editions. In any case, we may congratulate the author on having done something notable towards that revival of the aniline colour industry which we hope to see in Great Britain.

PRACTICAL ORGANIC AND BIO-CHEMISTRY. By R. H. A. Plimmer. New and Revised Edition. London, 1918: Longmans, Green & Co. 18*s*. net.

Our rather full notice of the original edition less than three years ago (*Journal of the Royal Society of Arts*, December 31st, 1915, page 134) makes it necessary to do but little more than call attention to the new and revised edition.

All the good features of the original edition characterise the present volume, with the advantage of revision and bringing up to date. General organic chemistry is well summarised in the 636 pages, and, as the title suggests, some emphasis is

laid on compounds and reaction concerned in the vital processes. The section on the analysis of tissues (pages 573–604) treats of the matter briefly as affecting inorganic constituents, and as regards organic constituents very fully and thoroughly, not only from the qualitative aspect, but also the quantitative, special consideration being given to those details and dates which assist in identification and determination where small quantities are concerned (micro-analysis).

Plimmer's "Practical Organic and Bio-Chemistry" has, by reason of its special merits and qualities, already taken up a standard position.

FITZHANGER MANOR, Ealing Green. By Arthur T. Bolton, F.S.A., F.R.I.B.A. Sold at the Soane Museum. 7*d*.

Fitzhanger Manor, which is now the Ealing Public Library, was from 1800 to 1811 the country retreat of Sir John Soane. This brief account of it has been written by the Curator of the Soane Museum, who suggests that a study of the building will be helpful as illustrating the origins and development of Soane's artistic ideas. Soane was an architect who planned a large number of important buildings. His notions were by no means conventional, and in his time he met with much hostile criticism and even ridicule. In view of this it would have been interesting to have fuller descriptions of Fitzhanger Manor than Mr. Bolton has given us, but the photographs are excellent.

The Soane Museum itself, in Lincoln's Inn Fields, is not nearly so well known as it ought to be. It contains a remarkable collection of works of art, antiquities, books, gems, illuminated manuscripts, and architectural designs which Soane himself formed for the benefit of his own and other students. The museum should possess a special interest for Fellows of the Society, which appoints one of the trustees.

GENERAL NOTES.

THE PRODUCTION OF DIAMONDS.—The Bakerian Lecture at the Royal Society was delivered by the Hon. Sir Charles Parsons, K.C.B., F.R.S., on "Experiments on the Production of Diamond." The paper alluded to some of the results of experiments described in papers by the author to the Royal Society in 1888 and 1907, more particularly those on the decomposition by heat of carbon compounds under high pressure, and on the effect of applying pressure to iron during rapid cooling. A description was given of experiments designed to melt carbon under pressures up to 15,000 atmospheres by resistance heating and by the sudden compression of acetylene oxygen flame, and by the firing of high velocity steel bullets through incandescent carbon into a cavity in a block of steel. Allusion was made to experiments on chemical reactions under high pressure and their results. The pressures occurring in rapidly cooled ingots of iron, and experiments bearing upon this question, were discussed. Experiments at atmospheric pressure and experiments *in vacuo* were described. The main conclusions arrived at were that graphite cannot be converted into diamond by heat and pressure alone, within the limits reached in the experiments; that there is no distinct evidence that any of the chemical reactions under pressure have yielded diamond; that the only undoubted source of diamond is from iron previously heated to high temperature and then cooled; and that diamond is not produced by bulk pressure as previously supposed, but by the action of the gases occluded in the metal and condensed into the centre on quick cooling.

PROPOSED CANAL FROM GENOA TO LAKE MAGGIORE.—Attention is drawn in the *Geographical Journal* to a scheme propounded by Professor Baggi, of Turin, for constructing a canal from Genoa to Lake Maggiore. It is described, with a sketch-map and section, in *Navigazione Interna* (Milan). Professor Baggi proposes to cross the mountains on the direct line between the two termini by a tunnel twelve kilometres in length. This enables the canal to cross the watershed at a maximum elevation of 250 metres. A calculation of the water required to operate the canal, and of the supply available above the summit-level from the streams descending the inner versant of the mountains, shows that these would amply suffice for the needs of the canal and for all other purposes. The cost of making the tunnel is estimated at 7,000,000 lire per kilometre. After crossing the Lemme on the north side of the watershed, a second short tunnel would take the canal into the basin of the Scrivia, the further route being by Tortona to Bassignana on the Po, and thence nearly due north to Ticino below Lake Maggiore. Aqueducts would be required for the crossing of certain valleys, but would be of no very great length in the aggregate.

MAT-MAKING IN HOLLAND.—For more than a century the making of mats from bulrushes and other varieties of rushes has been a house industry in the province of Overyssel, along the Zuider Zee, from which the province extends eastward to the German border. Men, women, and children are engaged in the work, which, however, seems to be poorly paid, as it is stated that the earnings are only 1*s*. to 1*s*. 6*d*. per day. Before the war large quantities of mats were imported from Germany. This having ceased, mat-making in Overyssel has greatly increased. In districts along the Zuider Zee, writes the United States Consul at Amsterdam, the industry is conducted largely for the purpose of freeing swampy lands from rushes, so that they can be drained and made arable. Much good farm land has thus been produced, particularly in recent years, since companies and municipalities have taken charge or supervision of this industry.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECONSTRUCTION AND THE REAL COST OF THE WAR.

By Edgar Crammond,
Late Secretary of the Liverpool Stock Exchange; Managing Director of B.S.T. Limited.

Lecture III.—Delivered March 4th, 1918.

In my two preceding lectures I have given brief summaries of our economic position before the war, and the principal changes which occurred during the first three and a half years of war. I now propose to discuss the real cost of the war and the problem of economic reconstruction.

Many people are attempting to measure the gulf which three and a half years of war has created between our pre-war economic system and the position in which we find ourselves to-day, and to form some conclusions as to the conditions which will probably obtain after the war. In my opinion, the old economic system, if we could be said to have had a system, has gone for good, and we could not return to it even if we wished to do so. The conditions of international trade have been profoundly modified. Women have proved their industrial capacity, and will not go back to pre-war conditions, while the Reform Bill, which will double the present electorate by adding 2,000,000 new men voters and 6,000,000 women, of whom 5,000,000 will be married, is destined to effect an enormous influence upon the political and economic life of the United Kingdom.

Our pre-war economic policy served us well. It increased production, it brought us a very large measure of prosperity, and it laid the world under tribute to us; but it was a subconscious growth, and it had grave defects which were becoming manifest in the form of labour unrest. We have been told on competent authority that if the war had not broken out there would have been an industrial revolution in this country. Women who were not employed were restless and dissatisfied. Production was looked upon too much as a source of profit, and not as a service to the whole community. Our internal trade was subjected to violent fluctuation, it was open too much to foreign exploitation; there was great irregularity in employment, and there was a want of co-ordination in the various efforts of the nation.

Ordeal by battle has shown the weaknesses of our old economic policy as well as its advantages. For centuries it was our practice to throw out from the centre, as it were, our different sources of strength. In pursuance of this policy we encouraged our people to emigrate to the remote parts of the world. We invested an immense proportion (practically one-fourth) of the national wealth outside the limits of the United Kingdom. We became the citadel of the international monetary system, and we opened our money markets to the whole world. Our investments abroad have proved of inestimable value during the war. They have been our real war treasure, and without them it is difficult to believe that we should have been able to finance our Allies and provide for our own expenditure. Under our Free Trade policy agriculture declined, and, as Mr. Prothero has pointed out, the factory and the furnace flourished by the ruin of English agriculture. But the greatest advantage we derived from our Free Trade policy was the development of British shipping. When the war broke out we owned one-half of the mercantile tonnage of the world, and it was the magnitude of our mercantile marine, and the fact that through its use we were able to call upon not only the Empire but the whole world for supplies of food and raw materials, that saved the Empire and our Allies from disaster.

The general tendency of our economic policy was to subordinate everything to the development of international trade and finance. The amalgamation of the joint-stock banks resulted in the draining of a large part of the liquid capital of the country to London, where it was employed in financing, carrying, and insuring world trade. The Stock Exchange, Lloyd's, and all the other great financial institutions, were engaged primarily in the development of world trade, rather than purely United Kingdom trade, although, of course, the one reacted on the other. We threw down all the barriers which restricted the freedom of commerce, and we became dependent upon foreign countries for more than half our supplies of foodstuffs and raw materials. At the same time, we allowed ourselves to become dependent upon Germany for supplies of commodities which were vital to the conduct of some of our greatest industries.

Germany, on the other hand, pursued an economic policy of centralisation. Notwithstanding the vast growth of her population during the past forty-five years, she, by means of the intensive development of her agricultural industry, became to a large extent self-supporting in the matter of food supplies. For many years she set her face against the emigration of her people, and it is only within a comparatively short period that she attempted to carry out a policy of colonial expansion.

The final purpose of economic labour is production to meet consumption, and I venture to think that in the past we paid too much attention to production and too little attention to consumption. There was waste in the production and consumption of food. The report of the Food (War) Committee of the Royal Society (Cd. 8421) showed that the amount of food produced and imported into the United Kingdom during the period 1909–13 was 15 per cent. in excess of the amount required to feed the entire population, and yet there is irrefutable evidence that a large proportion of the population was under-nourished. Then our industrial organisation was defective. There was waste in the production, consumption, and distribution of coal and motive power. "The present coal consumption would, if used economically, produce at least three times the present amount of power."* The Coal Controller estimates that, by bringing the consumption of coal as nearly as possible to the source it will be possible to save, roundly, 700 million ton-miles per annum. Again, we did not make the most economical use of our shipping. Under war conditions the carrying power in weight per 100 tons net of shipping entrances increased from 118 tons in 1914 to 143 tons in 1916.* (This latter result was largely brought about by the substitution of tramps for the big passenger steamships.)

Undoubtedly, a large number of people were engaged in services which were not essential to the national welfare. There were too many people employed in distribution and too few employed in production. The drink traffic was not sufficiently controlled. There were too many domestic servants, too many chauffeurs; and anyone who will take the trouble to examine closely the reports made under the Census of Production Act cannot fail to be impressed by the smallness of the national output in relation to our capacity to produce. The great industrial nations of the world were unsettled, and there was a growing feeling of anxiety to secure future supplies of foodstuffs and raw materials. The more progressive nations of the world were being transformed too rapidly from agricultural production to manufacturing production.

Paragraph 82 of the final report of the Dominions Royal Commission states: "During our journeys throughout the Empire we have been impressed by the fact, which is general in the world and which is not confined to any particular epoch, that the industries engaged in the utilisation of the land are less remunerative than city trades and the occupations of middlemen and merchants. Too much of the profit appears to go to the distributing interests and not enough to the primary producer. This tends to concentrate people to an undue extent in large cities and to withdraw them from country districts where their presence is most needed. Apart from the financial attraction of the city, life there presents greater amenities and greater excitement than do agricultural and pastoral pursuits. No universal remedy can be suggested, but we hold that everything which conduced to keep an adequate proportion of the population engaged upon the land or in country pursuits, everything which increases the attraction of agricultural life, should be regarded as beneficial to the development and strengthening of the community."

"Everywhere throughout the Empire we have been met by the complaint, to the accuracy

* Reconstruction Committee, Coal Conservation Sub-committee (Cd. 8880).

* Annual Report of the Liverpool Steam Ship Owners Association for the year 1916.

of which our own observation has testified, that the population is not inclined to settle on the land, or, if it has settled there, shows a strong tendency to leave it for the cities. Thus in Australia more than half of the total population, already small enough for so vast a continent, dwells in a few towns, nor is there any sign at present that these undesirable proportions are in course of change."

The question for us now to consider is what should be the lines of national economic development and what should be the national trade policy of the United Kingdom in relation to the rest of the world. In order to clear the ground for the consideration of these problems it will be well to deal first with the question of the real cost of the war and the reconstruction of the national finances.

From statements made by the Chancellor of the Exchequer on moving the fourth Vote of Credit, it may be assumed that the gross amount of the National Debt on March 31st, 1918, will be, approximately, £6,000 millions.

From this we are entitled to make the following deductions :—

	Millions. £	£
Loans to Allies and Dominions, including liability undertaken by India	1,500	
Less estimated amount of Loans to Allies which may be irrecoverable, say	500	1,000
Unsold Stocks in Ships, Raw Materials, Foodstuffs		250
Arrears of Excess Profits Duty		200
Value of Munition Works, Lands, etc., say		500
		1,950
Estimated net debt at the end of March, 1918		4,050

To this must be added the cost of carrying the war to a conclusion and winding it up, including demobilisation and the thousands of items which will have to be paid.

Demobilisation alone will probably take two years to accomplish, and it is estimated that during the first 12 or 18 months it will involve an expenditure of £2 millions per day. The winding-up of the war may therefore be estimated to involve a further net addition of at least £2,000 millions to the National Debt. But we cannot simply discharge these glorious men and leave them to find occupations for themselves in what may prove to be an overcrowded labour market. Justice and expediency demand that we should provide them with both adequate capital and adequate opportunities for employment. The very minimum we can fairly do is to place to the credit of every man who has served three years in the Army or the Navy a sum of £100, with safeguards which will provide that the money shall not be squandered. The aggregate sum required to pay this bounty will add £400 millions to the National Debt.

It may be objected that it is taking too sanguine a view of the situation to deduct from our war debt the whole of the amount which we have advanced to our Allies, and I therefore propose to omit the £500 millions which we have advanced to Russia.

If the course I have outlined above should be adopted, the total amount of the National Debt at the end of the war should be about £6,500 millions, exclusive of the capitalised value of pensions. How much of this vast sum can be truly described as lost? Only a comparatively small proportion, viz., that which has been borrowed abroad. I am in complete agreement with the following views, which were expressed many years ago by Sir Robert Giffen on the subject of the National Debt.

In his "Essays on Finance," First Series, Giffen said: "The National Debt is a mortgage upon the aggregate fortune of the country. As we may assume it to be practically all held at home we may reckon upon our whole estate without deducting the debt, whereas we should have to deduct it if it were held by foreigners; but while we do not deduct the debt from the total of our estate, neither can we add it without falling into error."

He emphasised this in 1889 in his book on the "Growth of Capital," and added: "Of course to each individual holding a portion of the National Debt, the holding is property . . . On the whole the reason assigned is a good one, but I should not censure very much any one who included the debt as a part of the capital of the community . . . the money expression of all the other capital of the community is less than it would otherwise be by the amount of the debt . . . if there were no debt, lands, houses, etc., would exchange for rather more than they do now. The debt in this view represents a certain distribution of part of the capital of the country, and we do not get a complete view of the capital unless we include it."

The National Debt at the end of the war will probably be in the neighbourhood of 40 per cent. of the amount of the national wealth before the war, and the vast amount which must be raised annually by way of taxation to pay the interest, even though the Debt is practically all held at home, somewhat weakens the complacent views which Giffen took when the National Debt was

only about 4 per cent. of the national wealth.

The real cost of the war may be summarised under the following headings: The death and disablement of, say, one million men. Human suffering and sorrow cannot be expressed in terms of money, but if an actuarial valuation had to be made this million of lives might be estimated to represent £800 millions. On March 6th, 1917, the Pensions Minister (Mr. Barnes) informed the House of Commons that the number of persons under the charge of the Ministry at that date were as follows: Disabled men, 157,544; widows, 62,796; children of the widows, 128,294; dependents of deceased men, 29,832; widows who had not reached the pensions stage, 125,000; men in hospital, 65,000; medically unfit, 65,000; total, 633,466. The Minister added that there were 300,000 people who would benefit by the new Royal Warrant, making the total number of persons who would come on the books of the Ministry 1,000,000. The scheme in its entirety, would, he said, involve a capital charge of £396,000,000, and in the first year £25,000,000. On March 26th, 1917, Mr. Barnes announced that at that time £72,000,000 was being distributed throughout the country by way of separation allowances and pensions. Under the new Warrant a further £26,000,000 would be distributed, making, in round figures, a total of £100,000,000.

Then we have diminished stocks of food supplies, raw materials and manufactured goods. We have a large diminution in our shipping tonnage and the remainder of our mercantile marine is not in such an efficient condition as it was before the war. Then we have parted with a considerable proportion of our investments abroad. In the years preceding the war we used to invest about £200 millions abroad and expend about £200 millions in the form of new investments in the United Kingdom, besides providing about £180,000,000 per annum for depreciation, renewals, etc. This latter provision has been largely suspended during the war. The community is poorer to the extent to which it has been deprived of many services, such as cheap and frequent train services, shipping services, etc., but this is largely a temporary loss and cannot be expressed in terms of money.

Altogether I think it would be a reasonable estimate to assume that, including the capitalised value of the war pensions and the moneys borrowed abroad our real loss during the war is in the neighbourhood of £2,000 millions, but against this must be set the increased power of production.

If we should finish the war with a National Debt of £6,500 millions, what is our National Budget likely to be? We should have first to provide, say, 5 per cent. for interest and sinking fund, which would mean an annual charge of £325 millions.

Before the war the Civil Government cost £97 millions per annum. We are committed to a large and expensive scheme of educational reform, and we know that old age pensions will cost £18,000,000 instead of £12,000,000. The recent increases of salaries in the Government Departments will involve a large annual sum, and on the whole it would be prudent to reckon that in the first years of peace the cost of Civil Government will not be less than £150 millions, while pensions will call for an annual provision of at least £50 millions per annum.

What is to be our peace outlay upon armaments? In the year before the war the Army cost £28,300,000. It is my own belief that, notwithstanding the proposed League of Nations, the British Empire will find it very difficult for some years to come to reduce its standing Army below 500,000 men, and its annual expenditure on the Army below £80 millions.

In the year before the war the expenditure on the Navy amounted to £48,800,000. Naval shipbuilding costs 70 per cent. more than it did before the war. The development of the submarine may alter the whole conception of sea-power, and we shall get off lightly if we can keep our expenditure on the Navy below £70 millions per annum.

The third arm, viz., Aircraft, is yet only in its infancy, and an annual expenditure of £20 millions on this service would not be excessive.

Summarising the conclusions arrived at above, it may be estimated that our post-war expenditure will be as follows:—

	Millions. £
Civil Government Charge	150
Army	80
Navy	70
Aircraft	20
Interest and sinking fund charge on National Debt	325
Pensions, etc.	50
	695

Say, about £700 millions.

It would not be unreasonable to expect that the Empire should take over some share of the burden of Imperial defence. The money cost of defending the Empire has naturally fallen

mainly upon the United Kingdom. Our burden of war debt per head will be about £140, while that of the Overseas Dominions will probably be very much less.

We may apparently look forward to an annual expenditure of £700 millions. How is this vast sum to be provided? The Labour Party propose "a special capital levy to pay off a very substantial part of the National Debt, chargeable, like the death duties, on all property." This appears to me to be wholly impracticable in the form in which it is suggested by the Labour Party.

The advocates of a levy on capital do not seem to have any conception as to the form in which the "capital" of the country exists.

The following is a detailed estimate of the wealth of the United Kingdom which I laid before the Royal Statistical Society in 1914* :—

That would remove more than £700 millions from the valuation. Then the capital of the non-tax-paying classes is estimated to amount to £1,000 millions. The Labour Party obviously do not propose that there should be a 10 per cent. levy on the funds of the trades unions and co-operative societies, friendly societies, and the deposits in the savings banks. Again, movable property, that is, furniture, works of art, represents another £1,000 millions. How would the 10 per cent. levy be obtained from this form of property? The advocates of a levy say "there need be no fear about a flood of realisations; there will be no need of realisations, it will be largely a matter of book entries." Surely they do not propose that the Government should merely take over *inter alia* one-tenth of the furniture and works of art owned by the inhabitants of the United Kingdom.

	Income. £	Number of years' Purchase.	Capital. £
Under Schedule A—			
Lands	52,219,000	25	1,305,475,000
Houses	223,913,000	15	3,357,195,000
Other profits	1,297,000	25	32,425,000
Schedule B—			
Farmers' Profits	17,457,000	8	139,656,000
Schedule C—			
Public Funds, less Home Funds	35,049,000	20	700,980,000
Schedule D—			
Quarries, mines, ironworks	23,109,000	4	92,436,000
Gasworks, waterworks	19,588,000	20	391,760,000
Canals, docks, fishings, etc.	2,607,000	20	52,140,000
Other public companies	199,082,000	15	2,986,230,000
Foreign and Colonial Securities and Coupons	50,828,000	20	1,016,560,000
Railways in the United Kingdom	46,099,000	25	1,152,475,000
Railways out of United Kingdom	28,016,000	20	560,320,000
Other profits and interest	16,654,000	20	233,080,000
Trades and professions (one-fifth of total income of £222,676,000)	44,533,000	15	667,995,000
Total under income tax			12,688,727,000
Trades and professions omitted, 20 per cent. of amount assessed, or £44,533,000, of which one-fifth is	8,906,000	15	133,590,000
Income of non-tax-paying classes derived from capital	100,000,000	10	1,000,000,000
Income from investments abroad or from shipping, banking and mercantile services not brought home	60,000,000	15	900,000,000
Movable property not yielding income, *e.g.* furniture, works of art, etc.	—	—	1,000,000,000
Government and local property	—	—	750,000,000
			£16,472,317,000

It is clear that a large part of the above aggregate of £16,472 millions would not be available for assessment to a levy on capital. In the first place it may be pointed out that the capital of professional men, *e.g.* doctors, solicitors, accountants, underwriters, etc., consists mainly of their expert knowledge and business experience, and in their case there would be nothing to assess but the comparatively small investments owned by these men.

Another huge deduction must be made in respect of Imperial and local Government property, the value of which was estimated in 1912 at £750 millions, and it is now in the neighbourhood of £1,500 millions.

In 1913 Sir Bernard Mallet, President of the Royal Statistical Society, estimated the capital wealth of the country on the basis of property passing at death at less than £11,000 millions. When all the necessary deductions have been

* "Economic Relations of the British and German Empires," *Journal of the Royal Statistical Society*, June, 1914.

made, it does not appear that a larger sum than £10,000 millions would be available for assessment. Let us assume that sufficient pressure was brought to bear upon the Government to impel it to attempt to enforce an average levy of 10 per cent. on this amount, what would be the result? Securities, land commodities, etc., representing an aggregate value of £1,000 millions, might be transferred from private ownership to the ownership of the State. The bulk of these assets could not be sold. but they might bring in an income of £50 millions per annum; but as the Government would have been entitled to 25 per cent. income tax. in addition to super tax, it would, in any event, have received £12,500,000 of the income. Again, it would lose the benefit of the death duties on this mass of property, which might be estimated to produce about £3 millions per annum. The net result would, therefore, be an additional revenue of about £35 millions per annum, less the expenses of valuation and collection, which would certainly be very considerable.

The national revenue for 1913–14 was £198 millions, of which £163 millions were derived from taxation and £35 millions from non-tax revenue. From what sources are we to obtain a peace revenue of, say, £700 millions per annum?

What the Government wants is income, not capital. The capital of the Government consists of the country's power of production. For the year to March 31st, 1918, the Chancellor budgeted for a revenue of £638 millions, including £224 millions from income tax and super tax, and £200 millions from excess profits duty; the latter duty will probably bring in £230 millions and income tax £250 millions, and the total revenue for the year will probably show an increase of £88 millions on the Budget estimate, making the aggregate revenue £726 millions.

There are many alternative methods of meeting the charge for the national Government after the war, but it is of vital importance that we should adopt a course which will impose the minimum of hardship and will not check our industrial development. We must remember also the paramount importance of keeping our financial policy as far as possible in line with that adopted by the other great industrial countries, *e.g.* America and Germany. We have already gone much further than either of these countries in the matter of direct taxation, and it would be unfortunate if the treatment accorded to capital should be so much more unfavourable in this country as to divert both home and foreign capital from London.

We might continue the excess profits duty, but this is open to very grave objections: (1) that it constitutes a restraint upon the development of trade and tends to standardise production at the low level of 1913, and (2) that it will probably cease to yield any substantial amount of revenue in a few years after the war. Of course, this duty cannot be suddenly dropped, but I think it should be fixed for a period of, say, five years ahead on a descending scale, say 50 per cent. in the first year of peace, declining to 10 per cent. in the fifth year after peace. Another course would be to increase the income tax and super tax, but income tax is already at an oppressive level, and any further substantial advance would impose a check upon individual enterprise at a time when it should be most actively encouraged. The death duties will doubtless be further increased, and they might possibly be advanced considerably without causing undue damage to the economic system. There must be a further increase in the indirect taxation. The case for the adoption of such a policy is very strong. The working-classes are getting a larger share of the gross income of the country than they have had in the past, and they are not contributing their fair proportion of the cost of government. The wages bill has gone up by, at least, £500 millions since 1914, but indirect taxation has only advanced by about £30 millions. In 1913–14 indirect taxation was 43 per cent. of the total revenue; for 1917–18 it will amount to only 18 per cent. of the total revenue. It should be possible to obtain at least another £50 millions a year from indirect taxation.

As soon as peace has been declared the country will have to consider very seriously whether it can afford to continue the present preferential treatment accorded to farmers in respect of income tax. For the year 1913–14 farmers were assessed to Schedule B on the basis that their profits equalled one-third of the rent. The fact was, of course, that farms under 450 acres paid no income tax. A few farmers were assessed under Schedule D, but even those assessed under Schedule B had the right, if their profits fell below the statutory one-third, to get a special reduction to the actual profits of the year. The method of assessment for the current financial year is similar, save for the fact that the Schedule B assessment, instead of being one-third of the rent (plus tithe), is now the full rent.

It must be remembered that farmers are exempt from the excess profits duty, the reasons given for this being (*a*) the putting up of the basis, together with the lower exemption limits and abatements, put a larger burden of new income tax upon the industry than it had ever borne before; (*b*) for this duty some sort of accounts are essential, and farmers generally do not possess them, even if they were compelled to keep accounts for the future they would be lacking for the pre-war standard. The £200 exemption limit would cut out a large number from liability, and reduce the amount payable by the remainder. The excess profits duty generally, the bringing in of nearly two million taxpayers, and the immense complications of income tax, threw such an enormous burden upon the depleted staff that it could not take on this extraordinarily difficult and not very profitable task; (*c*) it may be added that the State aid being given to agriculture production is net and not gross—that is, that it would have to be revised if new burdens were thrown upon farmers.

The gross production of farmers before the war was valued at about £200 millions. For the current year I estimate it to amount to £400 millions. In 1913-14 farmers' profits were probably £50 millions, and they were only assessed at £17 millions. For the year 1917-18 I estimate farmers' profits at not less than £120 millions, but they will only be assessed at £52 millions; that is to say, instead of contributing £15-£20 millions of income tax and excess profits duty they will not pay more than about £5 millions. As a result of this exemption from excess profits duty, the practical exemption from income tax, and the special treatment which has been accorded to them in other directions, it may be safely affirmed that the capital of farmers has been practically doubled during the war. But even if effect were given to the proposals outlined above, it would not produce sufficient revenue for the purposes of the Government, and the best course which we can take appears to me to be the institution of a small annual tax on capital, graduated so as to yield an average return of 1 per cent. per annum on the capital wealth of the country, and to be strictly limited to a term of ten years. An exemption limit of, say, £2,000 might be adopted. If such a tax were imposed it should yield a revenue of not less than £120 millions per annum in the United Kingdom. The method of assessment should be comparatively simple and inexpensive. Each taxpayer, when making his return to income tax, should be required to include a valuation of his capital. In case of dispute the valuation should bear a certain specified ratio to the gross income assessed to income tax, the ratios varying in relation to the nature and state of development of the property. The income tax returns would provide an annual check, but if there should be found to have been evasion the arrears could be recovered when the estate ultimately came to valuation for probate purposes. If effect were given to the above proposals, the post-war revenue might be as follows (the actual revenue for 1913-14 and the estimated revenue for 1917-18 are included for comparison):—

	Actual Revenue for 1913-14. Millions. £	Estimated Revenue for 1917-18. Millions. £	Estimated Post-War Revenue. Millions. £
Customs and Excise .	75	105	150
Estate Duties . . .	27	29	50
Stamps, Land Tax, etc.	14	10	15
Income Tax, say . .	47	250	250
Non-tax Revenue . .	35	69	70
War Tax on Capital .	—	—	120
Excess Profits Duty .	—	230	50*
Miscellaneous . . .	—	33	—
	£198	£726	£705

* Average for, say, 10 years.

It should, therefore, be possible, by increasing indirect taxation to £150 millions, by advancing the death duties and by instituting a small annual tax on capital, to meet our post-war charges, to abolish the excess profits duty in five years after peace, and to maintain the income tax at the present standard rate of 5s. in the £. In 1929 the Government will have the option of paying off the 5 per cent. War Loan, and many of the other Government obligations will become liable to redemption. It is probable that we shall then be in a position to reduce the rate of interest and consolidate the war debt, and if the monetary conditions are suitable we might issue a Consolidation Loan at the rate of $3\frac{1}{2}$ per cent. Of course, due consideration must be given to the condition of the money markets, the cost of living, and the rate of the income tax. A reduction of $1\frac{1}{2}$ per cent. interest on £6,000 millions would mean an annual saving of £90 millions per annum to the Exchequer. I think, therefore, that for the next decade we should adopt what I would term a transition stage in national finance, and at the end of that time reconsider our national economic policy.

Expenditure must always be considered in

relation to income, and we must remember that in 1914, when the Imperial expenditure was £200 millions per annum, the national income was about £2,400 millions per annum. That is to say, the cost of Government represented about 8 per cent. of the entire national income. What is the national income at the present time? In order to show this I have prepared the following estimate of the income and expenditure of the United Kingdom for the years 1907 and 1917 respectively:—

(in 000,000 £)

	1907.		1917.	
Food, etc.	483·1		875	
Dress	248·0		320	
House	246·0		260	
Miscellaneous	186·3		150	
Cost of distribution	200·0		300	
Professional and Domestic Services	100·0		60	
	1463·4			1,965
National Service, including Army and Navy, Local Government	184·0	War and other Expenses of Government incurred at home	1,800	
	1,647·4			
Depreciation, repairs, renewals, etc.	180·0	*Less* cost of feeding, clothing, and maintaining 6,000,000 soldiers and sailors, 2,000,000 munition workers and their dependents, allowed for above	300	1,500
New Investment at home	150·0			
Capital invested abroad	176·0			
	£2,153·4			£3,465

From the estimates furnished in the above table, it may be said that while in 1907 we produced commodities and services sufficient to feed, clothe, and maintain us, and leave a surplus of £506 millions for repairs and renewals and new investments at home and abroad, in 1917 we produced commodities and services sufficient to feed, clothe, and maintain us, and provide a surplus of £1,500 millions, which we devoted to the carrying on of the war, but there was practically nothing available in 1917 for renewals and new investments. This great surplus was produced partly by increased production, partly by restricting consumption, partly by using up accumulated stocks, and partly by the rise in prices. It will be noted that I estimate that the national income advanced from £2,153 millions in 1907 to about £3,500 millions in 1917. This estimate is borne out by the amount of gross income brought under the review of the Commissioners of Inland Revenue, which advanced from £980,117,000 in 1907–08 to £1,600,000,000 in 1916–17. The number of income tax payers in 1913–14 was 1,200,000 and in 1916–17, 3,200,000.

The solution of our domestic post-war financial problem can only be found by increased production. If we can maintain the production of the United Kingdom at not less than £3,600 millions per annum, the estimated Imperial expenditure of £700 millions per annum will not amount to more than 20 per cent. of the national income, and this is a burden of taxation which the nation should be able to bear with comparative ease.

I believe we can maintain the production of the United Kingdom at the level I have indicated if we profit fully by the lessons which the war has taught us as to our faulty ideas of commercial organisation and the unhappy relations that existed between capital and labour before the war. We were then only producing from two-thirds to one-half of the commodities and services we were capable of producing.

An interesting statement with regard to pre-war industrial conditions and output was made in a report of the Mechanical Section Committee of the Iron and Steel Institute issued in the latter part of 1917 as to the causes of the smaller output of steel in British steelworks as compared with foreign practice. On the question of labour conditions the report states: "there is a general agreement that our labour conditions, as compared with the Continent, are detrimental to output. It is not, however, suggested that this is due to inferiority of the men individually . . ."

The following is a comparison of melters' earnings in several countries before the war:—

EARNINGS PER SHIFT (PRE-WAR FIGURES).

	English.		American.		German.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
1st hand	36	11	17	4	9	6
2nd "	24	9	11	3	7	0
3rd "	18	3	9	9	5	6
Total	80	1	38	4	22	0

The weight of steel made per shift is approximately in the ratio of :—

English.	American.	German.
1·0	1·5	2·0

The report continued: "We look upon the question of labour as a most important one. The wages are so high that it is useless to expect men to make extra exertion to gain more. It seems, therefore, that in order to increase the output it is necessary to reduce the effort required from the workman by every possible means, and this can only be done by a well-laid-out and well-organised plant."

The accuracy of the above figures was challenged, but the general conclusions of the Committee appear to have been fully established.

A report by another Committee of the Iron and Steel Institute as to the causes of the smaller output of steel in British steelworks as compared with foreign practice stated that "Military training on the Continent makes the men there more obedient and methodical in their ways than in England . . ."

The opinion is expressed that if the steel trade of Britain is to hold its own in open competition with the other steel-producing countries of the world, it will be necessary, amongst other changes, to have a Control Board to which all orders will go and from whence the work will be allocated to the different works according to their ability to do it.

"It is clear to the Committee that the one outstanding feature which has been revealed by their work, so far as it has gone, has been the eliciting of the almost unanimous opinion that, if the steel industry of this country is going to maintain its position, it must be by some great broadening of our commercial organisations that would lead to economies far and away outweighing any other element in the situation, and long ago realised and adopted by our foreign competitors."

In my second lecture I have given my reasons for the belief that during the war the power of production of the United Kingdom has increased by 30 to 40 per cent., and I believe that, from the point of view of industrial expansion, the war has advanced us by two generations. The Coal Conservation Subcommittee of the Committee of Reconstruction in their Interim Report (Cd. 8880) give a most encouraging view of the prospects of increased production after the war.

The following is a summary of the conclusions of the Committee* :—

1. The coal consumption involved in the production of motive power in the United Kingdom amounts at the present time to 80,000,000 tons per annum, equivalent in value to, say, £40,000,000 at pit head.

2. In the industrial reorganisation which must take place on the termination of the war the further development of power is of great importance. The present use of motive power per employer is only about half that in the United States. Large quantities of electrical power will be required for the development and carrying on of new processes not at present undertaken in this country. Processes involving some millions of horse-power at present worked in America, Norway and Sweden, Germany, etc., can be profitably carried on, and having in view the desirability of making all essential products in the Empire, should be carried on in this country.

3. It is only by largely increasing the amount of power used in industry (by two or more times) that the average output per head (and, as a consequence, the wages of the individual) can be increased. The pre-war earning power, or wages, of each individual was far too low.

4. Power may be most efficiently applied to industry by the medium of electricity.

6. Technically and economically the electrical energy can best be provided by a comprehensive system which will provide for power production in large super-plants.

9. If power supply in the United Kingdom were dealt with on comprehensive lines and advantage taken of the most modern engineering development, the saving in coal throughout the country would, in the near future, amount to 55,000,000 tons per annum on the present output of manufactured goods.

10. If the coal so saved were used for the production of further power it would be possible to generate continuously not less than 15,000,000 horse-power, which would more than compensate for the absence of large water-powers in this country, and admit of the manufacture here of many products which are at present only made in America and on the Continent.

The average coal consumption per horse-power throughout the country has been halved during the last twenty-five years . . . the present coal consumption would, if used economically, produce at least three times the present amount of power.

Assuming that we can reconstruct the national finances on the lines I have indicated and at the same time increase our production over the pre-war level by about 50 per cent., what is the economic problem which we shall have to face after the declaration of peace? We shall have to provide work for four or five million men who are at present in the Army and Navy or employed as munition workers, and one million

* Reconstruction Committee, Coal Conservation Subcommittee Interim Report on Electric Power Supply in Great Britain. (Cd. 8880.)

women who are employed in munition works. At the same time we shall have to readjust our foreign trade policy to the new position which we shall hold in international finance.

A sub-committee of the executive of the Labour Party have put forward an interesting programme of reconstruction. The report states, *inter alia*, that, in order "to prepare for the possibility of any unemployment either during demobilisation or in the first years of peace, the Government should make preparations for putting instantly in hand . . . such urgently-needed public works as :—

(*a*) The rehousing of the population to the extent possibly of a million new cottages and an outlay of £300 millions sterling.

(*b*) The immediate making good of the shortage of schools, training colleges, technical colleges, etc., and the engagement of the necessary staffs.

(*c*) New roads.

(*d*) Light railways.

(*e*) The unification and reorganisation of the railway and canal system.

(*f*) Afforestation.

(*g*) The reclamation of land.

(*h*) The development and better equipment of our ports and harbours.

(*i*) The opening up of access to land by co-operative small holdings and in other practicable ways.

It is extremely disappointing to find that an important body who will have such a large share in the determination of the future economic policy of this country should have taken such purely domestic views of our post-war problems. We cannot afford such an extravagant programme of internal development until we have restored our position in foreign trade.

The report states: "To-day no man dares to say that anything is impracticable." I will dare to say that it is impossible to evolve a satisfactory and adequate scheme of economic reconstruction unless it is based upon (1) a great increase in the production of commodities and services in the United Kingdom, and (2) a vast expansion of our foreign trade. We all recognise that domestic reforms are urgently necessary, that our agricultural industry must be fostered, and that home industries, particularly the dye and chemical industries, must be greatly developed, but whatever paper schemes we may adopt we shall ultimately find that they are of little account unless they comply with the two conditions which I have laid down above. The extent to which we can expand our foreign trade is, therefore, a matter of profound importance.

The Government are at present spending in this country about £5 millions per day. During demobilisation they will not probably spend much more than £2 millions per day. Who is going to take the place of the Government as the purchaser of commodities or services to the value of £3 millions per day?

It will be a much more difficult task to move from war production to peace production than it was to move from peace production to war production. In the latter case we had at our disposal the wealth and resources accumulated through a century of industrial expansion. The manufacturer, in transforming his works, knew that he had behind him a Government contract at, to say the least of it, remunerative prices with no risk of bad debts or a falling off in the demand. How is the British manufacturer to shape his peace programme and to move from war production to peace production with a heavy burden of taxation and a problematical demand for his production and an unknown volume of competition from foreign manufacturers?

Before the war we imported mainly foodstuffs and raw materials and exported manufactured goods and coal, and it does not seem probable that the war will make any fundamental alterations in our dependence upon foreign trade. We shall make some progress in the matter of growing a larger supply of food at home, but it is quite out of the question for us to grow all the food we require at home. With regard to raw materials, we shall be still more dependent upon foreign supplies than we were in 1914.

By the command we had of the markets of the world, and the economic momentum which was given to our trade by the interest on our investments abroad and the earnings of our shipping, insurance companies, etc., we could determine in a large measure the nature of our imports. It is of vital importance that we should arrive at a clear understanding of our international position as it will appear after the war, and know whether we shall have this command of the markets of the world. Shall we still be a creditor nation? Shall we still have capital available for investment abroad on a large scale?

Before the war we entered upon each year of foreign trade with the comfortable knowledge that we should have at the end of it

a credit of about £400 millions made up as follows:—

	Millions.
Interest on Investments	£200
Earnings from Shipping	100
Earnings from Banking, Insurance, etc.	100
Total	£400

We therefore began the war the greatest creditor nation in the world because we carried, financed and insured more than one-half of the world's sea-borne commerce and the world was indebted to us for £200 millions a year by way of interest on investments. Our pre-war foreign investments have shrunk from £4,000 millions to £3,000 millions, but on the other hand we have made new investments abroad during the war to the extent of £1,500 millions. Before the war the foreign holding of our National Debt was negligible. It now probably amounts to £1,000 millions. If these conclusions are approximately correct we stand to receive only £225 millions as interest on investments, that is assuming our loans to our Allies and the Dominions are good (an assumption which is by no means justified at the moment). On the other hand we shall have to pay £50 millions per annum by way of interest on British Government securities held abroad. On balance, therefore, we should stand to receive £175 millions by way of interest on investments.

With regard to food imports, for the five years preceding the war our purchases, including drink and tobacco, averaged £270 millions per annum. We shall probably grow a larger proportion of foodstuffs at home, but even if we should be able to provide supplies for five days in each week, which I very greatly doubt, the cost of food for the two days will, owing to the increase in prices, probably amount to as much as the pre-war imports for three and a half days per week.

What are our earnings from shipping, banking, etc., services likely to amount to? Our mercantile marine has shrunk from over 20 million tons gross to between 16 and 17 million tons gross, but owing to the high freights that must obtain for some years after the war it seems not unreasonable to assume that our earnings from shipping will be in the neighbourhood of £200 millions per annum. Until the international financial system has been re-established it would not be reasonable to expect that our earnings from our share in the financing of international trade will approach the pre-war standard; but, on the other hand, earnings from insurance, underwriting, etc., will probably be increased, and the two items of banking, insurance, etc., should produce not less than £60 millions per annum.

We should, therefore, be able to count upon a credit balance of about £400 millions per annum, made up as follows:—

	Millions.
Interest on Investments held abroad	£225
Less Interest on British Government Stocks held abroad	50
	£175
Earnings from Shipping, etc.	200
Earnings from Banking, Insurance, etc.	60
	£435
Deduct from this, say, 5 per cent. on £700 millions of loans to Allies which may not bear interest for some years after the war	35
	£400

On the basis of these calculations we should, therefore, be nominally as well off as we were before 1915; but on the new basis of prices a credit of £400 millions after the war will not be worth anything like a credit of £400 millions before the war, and to this extent we shall be in a less favourable position in relation to international trade.

All the conditions essential to a vast development of international trade should be in existence after the war. The principal trading countries of the world have depleted their stocks of manufactured goods and raw materials, and all neutral countries which produce foodstuffs and raw materials have, under the stimulus of economic pressure, extended their power of production of these commodities. In our own case we have increased the power equipment of our industries. We have introduced labour-saving appliances and revolutionised our industrial methods. We shall have a larger industrial population, including women, than we had before the war, and when demobilisation has been in operation for a year or so our production—that is to say, our wealth-producing power—should be at least 50 per cent. greater than it was before the war.

One of the most difficult questions in connection with the expansion of our foreign trade will be the problem of the foreign exchanges, some of which are now heavily against us. We do not know with any accuracy the extent of foreign holdings of our Treasury Bills, Exchequer Bonds and Currency Notes, etc., but we do know that the aggregate amount must be very considerable. In November last Mr.

Bonar Law told us that we were then indebted to the United States to the extent of nearly £400 millions. We have paid large sums to Holland for Java sugar and large amounts to Japan for ships and munitions. We have paid large sums to South America for foodstuffs and raw material, and it is common knowledge in the City that the great American financial institutions are employing very large sums in the London Money Market. With regard to Egypt, the *Times* of November 28th, 1917, stated: "There is ample evidence that practically the entire surplus income of the country (*i.e.* Egypt) since the outbreak of war, computed at about £40 millions, had been invested in War Stock, principally British." The building up of our gold reserve is, therefore, a matter of the first importance.

Altogether, I estimate that from the beginning of the war down to the end of 1917 we borrowed abroad, or obtained credits abroad through the sale of investments amounting in the aggregate to—

Millions.	
£350	in 1915
600	in 1916
900	in 1917
£1,850	

Of this total about £850 millions represent British holdings of foreign securities, principally American, which we have sold back to America, Japan, etc., leaving us with a net indebtedness of, say, £1,000 millions. Against this we may place the remainder of our pre-war foreign investments, say . . . . £3,000 millions

Add Investments made abroad during the war (that is loans to the Allies and Dominions), say	1,500	,,
	4,500	,,
Less moneys owing to the United States, etc.	1,000	,,
Balance	3,500	,,

The conditions under which our foreign trade will be carried on during the years immediately following peace, cannot possibly be the same as before the war. We shall probably have to pass through a transition stage which may extend over a decade. During the five years preceding the war we used to invest about £200 millions per annum by way of loans to Colonies and foreign countries. On the present basis of prices this average would represent a value of £400 millions per annum, but if we intend to make good our war losses as quickly as possible and provide employment for the men who are coming back and the munition workers who will be discharged, we must make provision for the investment of much larger sums abroad in the transition period. I think it should be not less than £600 or £700 millions per annum. This is quite feasible. In its ultimate form it represents the excess of production of commodities and services over the consumption of commodities and services. It should be quite practicable for this country, while relaxing the war strain on the industrial population, to produce £800 or £900 millions more services and commodities than it consumes, provided the co-operation of capital and labour is obtained.

The weakest point in our position is that of shipping. We have lost about four million tons, and the remainder of the tonnage is in need of repair and overhauling, but the new shipbuilding programmes in this country and America should improve the position.

It is a national misfortune that the nation should have been manœuvred into an attitude of hostility to the shipowners. Thanks to private enterprise, we possessed at the outbreak of war a vital and incomparable weapon without which the nation could not have carried on the war. The course of freights since the Government requisitioned shipping has proved conclusively that the shipowners, in allowing the law of supply and demand to take its course in fixing rates, were acting on sound and, in the circumstances, inevitable lines, and that the charge of profiteering was due to the economic ignorance and the jealousy of sections of the British public. The recovery of this country from the economic wastage of war will be gravely menaced if the State attempts to continue a day longer than is absolutely necessary the control of shipping, and I would suggest that our shipowners should take the Labour leaders into their confidence and discuss this vital question, for on a clear understanding of the issue the future of the British Empire must largely depend.

We shall have to grant loans to foreign countries and the Dominions on a vastly greater scale than ever before, and this we can most easily do by the creation of joint-stock companies.

The whole ground should be comprehensively surveyed. We must see what tonnage we are likely to have, what supplies of raw materials will be available, what our principal foreign customers require, what we can manufacture, and what they can sell us in exchange, and

then form overseas development corporations for Canada, Australia, India, South Africa, New Zealand, West Africa, Egypt, Mesopotamia, Palestine, East Africa, and the Crown Colonies. We must also provide for the development of trade with Belgium, France, Italy, Serbia. It will not be an easy matter to hold the balance between the claims of our different Allies for the expansion of our trade, but it is obvious that the development of Empire trade must be our first consideration.

During the war we have evolved the machinery requisite for the transference of a great portion of the resources of the country to the State, *i.e.* through War Loans. In the transition period we must provide machinery for the retransfer of these resources from the State back to the individuals—that is, from War Loans into oversea joint-stock enterprises. The banks must either provide loan facilities on a vast scale or establish a great national loan institution, which will accept War Loans, National Bonds, etc., as collateral, and issue in exchange therefor credit notes, which could be applied for the purpose of subscribing capital for these overseas enterprises in such a manner as will prevent inflation of credit. Unless some such machinery is provided, there is a danger that the market will be flooded with sales of war stock, etc., by holders who wish to take up again their industrial and commercial occupations, and require cash for the purchase of manufactured goods or raw materials.

Any attempt to exploit the Crown Colonies or the overseas Dominions, or foreign customers, for the purpose of liquidating our war debt will prove impracticable, and will lead to disaster. The whole scheme must be conducted on a strictly business basis; but, above all, the machinery for the expansion of our foreign trade must be kept as far as possible out of the control of the bureaucrats.

Concurrently with this vast expansion of our foreign trade we must be prepared with an equally big scheme of Empire settlement. Before the war emigration was proceeding from the United Kingdom at the rate of 300,000 per annum. It may be confidently assumed that this rate will be accelerated after the war. There can be no question as to the need for this if the Empire is to maintain its position in the world. An interesting comparison between the British and Roman Empires is made in the final report of the Dominions Commission. It states: "The Roman Empire, being concentrated and continuous, escaped some of the difficulties which confront the British Empire. The extreme distance between the capital and its furthest dependence was at the most 2,000 miles, whereas the extreme distance between London and the outer borders of the farthest self-governing Dominion is over 12,000 miles, or half the circumference of the earth. In a sense, such spaces have been annihilated by the use of electricity, and their inconvenience mitigated by that of steam. Still, as the present war teaches, routes so extended must always remain open to attack, and add to the anxieties of Government.

"Where figures are concerned certain salient facts emerge from the shadows of the past. The approximate size of the Roman Empire was 1,400,000 square miles. Canada, with nearly 4,000,000 square miles, and Australia, with 3,000,000 square miles, are each more than double this size. If to those areas be added that of the British Isles, with the three smallest of the self-governing Dominions—namely, New Zealand, the Union of South Africa, and Newfoundland, about 750,000 square miles in all—it will be seen that those portions of your Majesty's Empire alone overpass the area of that of Rome in a ratio of five to one.

"Again, an approximate estimate of the population of the Roman world in the time of its greatest prosperity was 85,000,000. In all the regions conquered by Rome there were indigenous populations of varying density.

"In the self-governing portions of your Majesty's Empire we find that their 65,000,000 inhabitants (including more than 5,000,000 natives in the Union of South Africa) are most unequally distributed. Of these no less than 45,000,000 live in the small islands which form the United Kingdom, leaving but 20,000,000, inclusive of all populations of non-European blood, to occupy the more than 7,000,000 square miles of the five oversea Dominions. It is, however, in the scale on which the population migrated from the homeland to the outlying parts that there lies the most striking contrast between the ancient Empire and those parts of your Majesty's possessions to which our inquiries have extended.

"Rome was not a colonising power in our sense of the word, but one whose chief object was to rule and hold. In her case the occupation and development of the distant parts of the Empire was not the lifework of hundreds of thousands of the best of her citizens. Her settlements were confined to the establishment of small groups, largely composed of disbanded

legionaries, in selected centres on frontiers, military highways, and trade routes.

"British rule is directed to ends widely different in character. Its policy is not merely directed to secure settlement in chosen spots, but to encourage it in all the wide areas within the Empire's boundaries, suited for the maintenance and well-being of its people. All that is asked of those who find a new home overseas is to assist in the development of the country of their choice in whatever manner best suits their training and inclination."

We could not have built up and held the British Empire if we had not encouraged our people to emigrate, and it cannot be doubted that the United Kingdom has attained a much more powerful position in the world and a greater efficiency in war from the emigration of her sons and daughters than she would have attained if she had restricted their emigration.

A general process of consolidation and reorganisation is going on throughout the country, both with regard to capital and labour. The great joint-stock banks are amalgamating. The shipping companies and great industrial undertakings, such as coal, iron, and steel, are amalgamating. Employers are consolidating their forces into a smaller number of federations, while the Labour Party has been reorganised, and the women are developing their organisations. Our Consular system has been reorganised and an Overseas Intelligence Department elaborated. But all these measures will bear little fruit unless there is co-operation between capital and labour, which will result in a great increase of production.

There is a widespread disposition to underrate the achievements of this country in the matter of organisation for war. We began the war with an Expeditionary Force of 160,000 men. We have now over 3,000,000 men serving overseas. We have in Mesopotamia one of the largest armies that has ever been assembled east of Suez. We have got large armies in Egypt, Palestine, and Salonika. In addition to maintaining and feeding our own troops, we are supplying war materials, food, etc., on a scale sufficient to maintain 3,000,000 fighting men of our Allies. Our economic position is perfectly sound. We have entirely revolutionised the character of our national production, and we are now producing commodities and services nearly equivalent in value to the commodities and services requisite to maintain our population at home and to carry on the war, and I see no reason to doubt that Great Britain can continue to carry this stupendous burden if the people do not weaken in their resolve, and provided we maintain our mercantile marine.

GENERAL NOTES.

Comparative Uses of Wood, Steel, and Concrete Poles.—Mr. F. L. Haushalter, writing in the *Electrical Review*, Chicago, discusses the costs of poles for use on telegraph, telephone, or low-voltage power lines under urban or inter-urban conditions. He considers that treated wood is best for these purposes, partly because the tree had been naturally adapted to resist stresses precisely similar to those to which the pole is exposed. Concrete poles compare favourably with steel poles at the prices worked out by the author, but something depends on local conditions and needs. Little is known as yet as to the life of concrete poles, though it has been found that moisture, absorption, and repeated drying-out affect certain grades of concrete. The life of steel embedded in concrete is thought to be practically indefinite. The greatest disadvantage in connection with concrete poles is the fact that they are of great weight, and cannot be so readily transported as steel poles; they are therefore usually made on the ground where they are to be used. There is also the difficulty of obtaining good sand and water.

British Manufacturers and Oversea Markets.—The most frequent charge levelled at British manufacturers, says the *Board of Trade Journal*, is that they are—or were—unwilling to make goods in accordance with the requirements of a particular market. It is probable that this charge had less evidence to support it than has been generally supposed. It assumes for its truth the existence of a system of standardisation among British manufacturers generally which is not apparent to investigators. How, then, did the belief become almost universal that British manufacturers are less adaptable to overseas conditions than their German rivals? The reply is, first, that many British manufacturers have in the past neglected to study the overseas markets with the meticulous care devoted to them by the Germans: and, secondly, that the oversea buyers have not explored with sufficient patience the field of British production. In the new world upon which we shall enter after the war is over, British firms will still have to contend against and break down a deep-rooted conviction abroad that they are rigidly conservative. In the meantime they can emphasise their readiness, whenever it is practicable, to make the goods which their customers want to buy.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, AUGUST 23, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

EXAMINATIONS.

The results of the Elementary Examinations (Stage I.), held from May 6th to the 15th, were sent to the centres concerned on the 19th inst. The results of all three stages of both the March and May examinations have now been issued.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

HIGH TEMPERATURE PROCESSES AND PRODUCTS.

By Charles R. Darling, A.R.C.Sc.I., F.I.C.

Lecture I.—Delivered January 21st, 1918.

In comparing workshop processes at present in use with those employed twenty years ago, many striking changes may be noted, all tending to cheaper and more rapid production. It will be found, on examination, that some of the most important of these changes are due to the utilisation of high temperature processes, or to appliances in which new materials, produced at high temperatures, are employed. The surfacing of metals, the boring of metal cylinders, the cutting of granite, marble, and other stones, and many other operations which involved the use of steel tools, are now frequently carried out by grinding, the abrasive material being usually an electric furnace product. In another direction, the use of the oxy-acetylene flame for cutting iron plates, and for welding, has proved of immense importance, and is now quite indispensable; and here again the material which has rendered the extensive use of acetylene possible—calcium carbide—is made in the electric furnace. A further important development has been the introduction of "thermit" processes, in which aluminium is used as a reducing agent with the production of an extremely high temperature; and here also the electric furnace is involved as an essential to the production of aluminium. At the present time, when the economic generation of electricity in this country by the aid of large, central power-stations is under consideration, the present and future importance of high temperature processes and products cannot be too strongly emphasised. In any scheme that may be evolved, provision should be made for electric furnace work on the large scale, as otherwise we shall remain, as heretofore, dependent upon other countries for most of the materials dealt with in the present lectures.

For our immediate purposes, a high temperature process will be considered as one that cannot be conducted by the combustion of ordinary carbonaceous fuel in air, and which therefore demands the production of a temperature above 1700° C. This degree of heat may be exceeded by special methods of combustion, or, better still, by the aid of electricity. In chemical actions the energy set free appears in the form of heat, and produces a temperature which, in any given case, cannot exceed a certain maximum; and no instance is known in which a temperature higher than 3000° C. is obtained by chemical means. In the case of electrically produced heat, a conversion of energy takes place without chemical action, and the temperature procurable is only restricted by the dissipation of the material in which the heat is generated, so that in practice 3700° C. can readily be produced.

Chemical actions are profoundly influenced by temperature. In almost every case combination is impossible at very low temperatures, such as that of liquid air (−184° C.); and on the other hand, at temperatures of the nature of 6000° C.—approximately that of the sun—compounds cannot exist. It follows that in every case there is a definite temperature at which combination will commence, and a certain higher temperature at which the compound produced will decompose. Mercury, for example, when heated nearly to its boiling-point, combines with oxygen to form mercuric oxide, and liberating heat according to the following equation:—

$$Hg + O = HgO + 207K \text{ (kilo-calories)}.$$

When, however, the oxide is heated to about 500° C., the equation is reversed, mercury and oxygen being set free, and 207K absorbed from the source of heat. It is evident that in all

cases the temperature produced by a chemical action cannot exceed that at which the decomposition of the product commences, and it is this factor that chiefly determines the temperature actually obtained in any given case. Calculations are sometimes made with a view to finding the temperature of a reaction from thermo-chemical data; but owing to the restriction stated above the results are frequently very far from the truth. As an example, 2 grams of hydrogen combine with 16 grams of oxygen to form 18 grams of steam, 68·4K or 68,400 gram calories of heat being liberated. If all this heat were applied to the steam produced, the resulting temperature should be $\frac{68,400}{18 \times \cdot 5} = 7600^\circ$ C., the specific heat of steam being approximately 0·5. In practice, however, the temperature obtained by burning hydrogen in oxygen is about 2500° C., or only about one-third of the calculated value, owing to the attainment of the limit at which the reaction would reverse.

When a combustible material is burnt in air the temperature is lower than when pure oxygen is used, owing to a large part of the heat being carried away by the nitrogen, which forms four-fifths of the air, and takes no part in the chemical reaction. Increasing the rate of combustion by means of a blast produces a higher temperature with all kinds of fuel; but in no case is the degree of heat attained comparable with that procured by the use of pure oxygen. The combustion of coal gas in air, with a view to obtaining high temperatures, has received considerable attention during recent years. High pressures result in higher temperatures, and in this connexion Sir Robert Hadfield has recently called attention to some early experiments of Bessemer, in which pressures of the nature of 100 atmospheres were employed, and has suggested that further research on these lines is desirable. It is worthy of note that the temperature obtained on firing the compressed charge in a gas engine is about 2000° C. In another direction, Professor Bone * has shown that when coal gas and air are caused to burn without flame in the pores of a solid, a temperature approaching 2000° C. may be obtained. By altering the ratio of gas to air, and making provision against "firing back," Méker has produced a burner which gives a much higher temperature than an ordinary Bunsen flame, exceeding the melting-point of platinum (1753° C.). At present, however, no means have been discovered of burning a mixture of coal gas and air so as to produce the temperatures requisite to conduct the processes dealt with in the present lectures. The regenerative system of heating, introduced by Sir William Siemens, and now in general use in steel-smelting furnaces, is capable, theoretically, of producing temperatures of 2500° C. or more; but in practice is restricted to the point at which the refractory material used as lining for the furnace, and for the pre-heating chambers, undergoes destruction, the limit with silica bricks being below 1800° C. Even if a refractory capable of withstanding 2500° C. could be procured in sufficient quantity, it is doubtful whether this process could to any extent supersede the electric furnace for operations at very high temperatures. Greater possibilities in this direction would be opened out if oxygen could be produced so cheaply as to permit of its use in large furnaces; but under existing conditions fuel combustion cannot compete with electricity in the highest regions of temperature. The fact that oxygen is a waste product in certain processes for fixing atmospheric nitrogen may, however, lead to important developments in fuel furnaces. It may be pointed out here that, in general, a higher temperature may be obtained in the interior of a furnace than in the open, as in the former case the heat losses are due only to conduction through the furnace walls, whilst in the latter a far greater loss occurs owing to convection and free radiation. As the heat radiated from a hot substance increases as the fourth power of its absolute temperature, it follows that the production of high temperatures in the open is opposed by radiation in a rapidly increasing degree as the temperature rises. The specific radiating power of flames containing no solid matter, such as the oxy-hydrogen, is very small; but is high in the case of a solid fuel burning in air or oxygen, and the temperature attainable in the open is thus seriously reduced.

With this brief statement of the conditions affecting the production of high temperatures, we may now proceed to enumerate the successful methods which are of practical utility, and to indicate the uses of each. These are summarised in the table on page 623.

The temperatures given can only be regarded as approximate, as determinations by different observers vary by 100° or more, according to the type of pyrometer used. It will be seen, however, that all greatly exceed the temperatures attained in ordinary furnaces. The various methods and their uses will now be considered.

* Howard Lectures on "Surface Combustion," 1914.

Process.	Approximate temperature (Degrees C.).	Practical uses.
Oxy-hydrogen flame	2,500	Smelting of metals; welding; metal-spraying; working of vitreous silica.
Oxy-acetylene flame	3,000	Cutting of metal plates; welding.
Electric arc	3,700	Welding; production of nitrates from atmospheric nitrogen.
Thermit	2,500–3,000	Welding; production of carbon-free metals and alloys.
Electric furnace	3,700	Smelting of various metals; production of compounds such as calcium carbide, carborundum, graphite, etc.; manufacture of alundum, and vitreous silica.

in the order in which they appear in the table given.

The Oxy-hydrogen Flame.

The intense degree of heat produced when a jet of hydrogen is burnt in oxygen was first observed by Dr. Robert Hare, of Philadelphia, who invented the oxy-hydrogen blowpipe in 1801. In a description of his experiments, published in the following year, Hare stated that he was "enabled to fuse several of the pure earths which had previously been deemed infusible, and likewise, not only to fuse, but to volatilise pure platinum." At a later date, by multiplying the jets and using high pressure, Hare succeeded in fusing more than two pounds troy of platinum into a malleable mass.

One of the chief uses of the oxy-hydrogen flame since its inception has been to smelt platinum and allied metals, and to produce alloys of these metals. Deville introduced a furnace made of lime, into which the flame was directed through a hole in the top, and this form of furnace is still in existence for smelting platinum. Amongst the useful alloys prepared by this process may be mentioned those of platinum and iridium, used for fuze-wires in detonators for military purposes, and also for thermo-electric pyrometers; and platinum-rhodium alloys, also used in pyrometers. Iridium, owing to its hardness, is used for the tips of fountain pens. The advantage of the oxy-hydrogen flame in this connexion is that no impurities are introduced, as might be the case if electric smelting were substituted. Small welding operations on articles constructed of platinum are also carried out by means of the oxy-hydrogen flame.

The welding of iron can also be accomplished by this source of heat, and equipments for this purpose have been used in the repair of boilers, etc., as an alternative to patching and riveting. The oxy-acetylene flame, being hotter, is now more generally used for this and similar purposes, as will be described later.

One of the most recent applications of the oxy-hydrogen flame is to the spraying of metals on to cold surfaces. In what is known as the Schoop process the metal, in the form of wire, is fed into the interior of the flame, where it is melted and then blown by compressed air, in a state of very fine division, on to the surface to be coated. The arrangement is such that when the size of the flame is increased or decreased, the feed of wire is changed simultaneously, so that the rate of deposit per unit area is constant. The finely-divided metal fills all the interstices of the surface upon which it impinges, and becomes firmly attached; and by continuing the process any desired thickness may be deposited. By this method surfaces may be coated with metals of high melting-points, such as nickel, and the working costs are low. The figures appended indicate the consumption of materials involved in the case of several metals (see table on page 624). As might be expected, the metals of higher melting-points require more hydrogen and oxygen, and, owing to their less fluid condition, a stronger blast of compressed air to atomise and project on to the surface.

It is found in practice that a coating of metal may thus be formed on wood, plaster, glass, pottery, and even on fabrics, as well as upon the surface of other metals. Thus a wooden object may be strengthened by a coating of brass; medallions obtained by spraying on to plaster, which is afterwards removed; seamless metal tubes may be made by spraying on to a detachable former; and wooden tanks may be lined *in situ* with copper or other metal. Structural steelwork may be protected from corrosion by coating with zinc or aluminium, and many other applications could easily be found. It is

One Square Foot of Surface Sprayed to a Thickness of One-Thousandth of an Inch.

Metal.	Weight sprayed.	Time.	Hydrogen used.	Oxygen used.	Compressed air used.	Cost, not including cost of metal.
	Grams.	Minutes.	Cubic feet.	Cubic feet.	Cubic feet.	*d.*
Copper	20	1·5	3·5	1·2	60	0·7
Zinc	17	0·4	0·5	0·17	15·5	0·25
Aluminium	6	0·6	0·6	0·2	22·5	0·3
Lead	26·5	0·1	0·2	0·07	4·3	0·08
Tin	18	0·25	0·35	0·12	9·0	0·08
Brass	17	1·0	1·6	0·55	40	0·5
Nickel	10	2 0	4·2	1·4	80	1·5

interesting to note that aluminium, which cannot be deposited by electrolytic means, is made available for surfacing by this process. The development of metal-spraying in this country has been hindered by the war, but all indications point to an extension of the process in many directions when normal conditions are restored.

[Samples were exhibited at the lecture, showing the results of spraying metals on to wood, plaster and fabrics.]

A further use of the oxy-hydrogen flame is in connexion with the manufacture of articles from transparent silica. This material has a much higher softening temperature than glass, and cannot be worked in an ordinary blowpipe flame. Under the high temperature of the oxy-hydrogen blowpipe, however, silica articles of all kinds can be made readily, as the material may then be manipulated in the same manner as glass. There are also many minor operations in which the oxy-hydrogen flame is found useful, such as the autogenous soldering of metals, and in all cases where an ordinary blowpipe does not furnish the requisite degree of heat. A coal-gas flame, fed with oxygen in a blowpipe, is frequently used for the autogenous soldering of lead and other metals, and the temperature produced approximates to that of the oxy-hydrogen flame. The general use of coal gas for work of this type, however, is restricted owing to the impurities present. Attempts to weld cast-iron with coal-gas flame have met with a certain degree of success, and it is possible that this source of heat may find extended applications for special work, being cheaper than the oxy-hydrogen flame.

The Oxy-acetylene Flame.

When acetylene burns in oxygen, forming carbon dioxide and water, the following equation is realised :—

$$C_2H_2 + 5O = 2CO_2 + H_2O + 294{,}000 \text{ calories.}$$

If carbon dioxide and water were the only compounds present in the flame, the temperature attained could not exceed that of the oxy-hydrogen flame, and would probably be less, as the decomposition temperature of carbon dioxide is lower than that of water. The equation, however, only represents the final products of the reaction, and in practice the inner portion of the flame consists of carbon monoxide, which does not dissociate below 3000° C. An oxy-acetylene flame consists of an intensely luminous centre, containing free carbon, at the tip of which is a whitish cone in which carbon monoxide is largely present, and which is the hottest part of the flame. Round the inner flame is a layer of hydrogen, which at the temperature produced cannot combine with oxygen on the inner side, but which burns to form water on its outer side; and similarly the carbon monoxide burns to form dioxide in the exterior and cooler part of the flame. The temperature of the inner white tip approximates to 3000° C., being thus much hotter than the oxy-hydrogen flame, and this superior temperature, combined with other properties, renders the oxy-acetylene flame capable of performing operations of many kinds with ease, which can only be accomplished with difficulty, if at all, by other kinds of flame.

The cheap production of calcium carbide in the electric furnace has made possible the extended use of acetylene, and furnishes an example of how one high temperature process may give rise to another. The manufacture of carbide will be dealt with later; in the present connexion we shall only consider it in relation to the production of acetylene, which is formed

by the action of water on calcium carbide. There are two systems in use for producing acetylene—"water to carbide," in which a small quantity of water falls on to a mass of carbide, as in acetylene lamps; and "carbide to water," in which a small feed of carbide is supplied to a large mass of water. The latter method is preferable for generating sets used for welding and cutting, or for large-scale production generally, as the gas produced is cooler. The liberated gas contains impurities such as sulphur and phosphorus, which are removed by passing through a purifier before the gas is used for work on metals. Acetylene cannot be safely stored in cylinders under high pressure in the same manner as oxygen, but by using

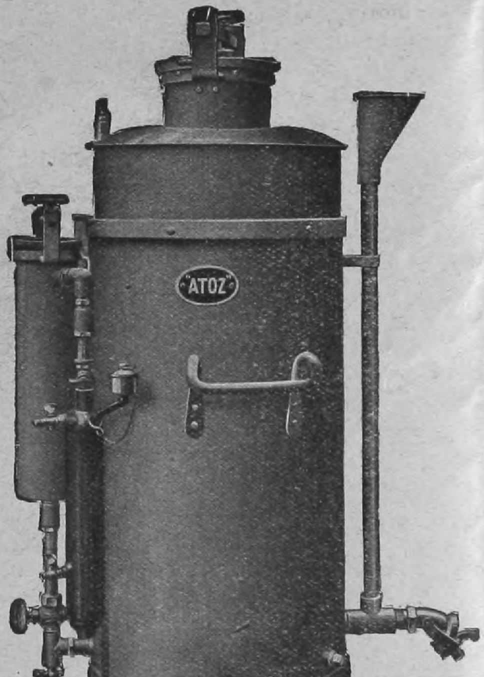

FIG. 1.—"ATOZ" ACETYLENE GENERATOR.

cylinders containing porous earths and acetone, large quantities of the gas may be compressed without danger, the acetone acting as a solvent, and the porous earths absorbing the gas. On opening the valve of the cylinder the acetylene escapes freely, its solubility in acetone and the quantity held in the pores of the earths diminishing as the pressure is reduced. Charcoal is frequently used as an alternative material for holding the gas under pressure. In high-pressure outfits, a cylinder of acetylene and one of oxygen are mounted side by side on a trolley for portability, both cylinders being provided with pressure gauges. In low-pressure outfits an acetylene generator replaces the cylinder, and provision is made to liberate the gas regularly only as required; a purifier, through which the gas passes, forming part of the apparatus. Amongst well-known equipments of this type are the "Atoz" generator (Fig. 1), which is of the "carbide to water" variety, and made by the Acetylene Corporation,

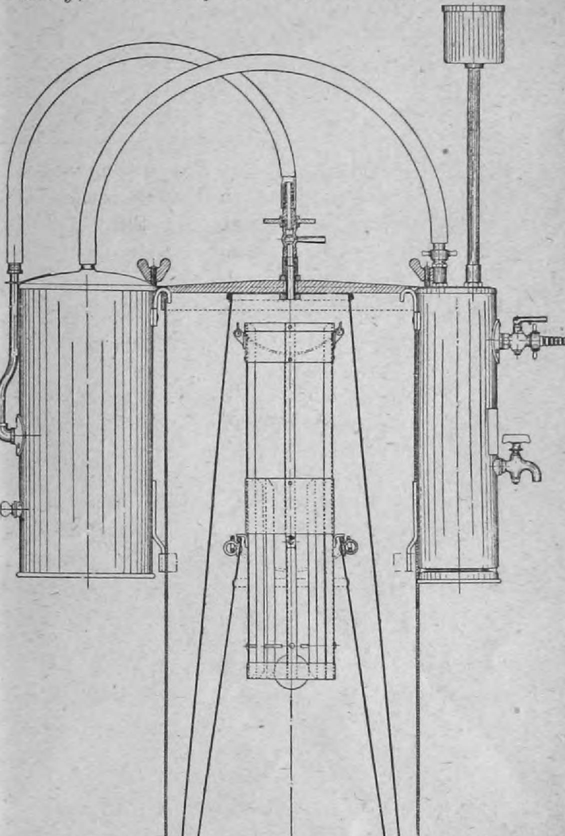

FIG 2.—"CARBIC" ACETYLENE GENERATOR.

Ltd.; and the "Carbic" generator (Fig. 2), made by Carbic, Ltd. In the latter apparatus cakes of prepared calcium carbide are used, in which the granules are coated with a material soluble in water, but impervious to atmospheric moisture, so that exposure to air does not cause decomposition as in the case of untreated carbide. In use, the cakes are suspended in a cage, and water is allowed to rise into contact with them, dissolving the coating and freeing the particles of carbide, which immediately

react with the water and liberate the acetylene. As the cake breaks up the pieces fall on to a fixed plate and there decompose; and when the escape-cock is turned off, the pressure of the gas forces the water away from the carbide, when generation ceases.

In using the oxy-acetylene blowpipe, the speed of exit of the gases should be from 100 to 150 metres per second; and this is secured on the high-pressure system by admitting both gases at a pressure of ·3 to ·4 of an atmosphere above the surrounding air pressure. In the low-pressure system, the entering oxygen acts as an injector, and is admitted at 1 to 1·5 ats. above atmospheric pressure, so that the mixed gases, before burning, possess the velocity stated above. Blowpipes used for welding contain a special chamber in which the gases are mixed before burning, and are provided with taps to regulate the supply of both oxygen and acetylene, so as to enable a flame of suitable size and character to be produced. This flame is made to impinge on the work, a rod of the metal undergoing welding also being held in the flame; and as both the work and the rod become thoroughly molten, a complete union is obtained. The free hydrogen round the working part of the flame is extremely beneficial in preventing oxidation, and enables a clean job to be made. When the material to be welded is massive, pre-heating is necessary in a fire or furnace, as the heat might otherwise be conducted away so rapidly that a satisfactory weld could not be obtained. Pre-heating always leads to economy in gas, and is generally resorted to in cases where the thickness of the material to be welded exceeds ¼ inch. The consumption of gases in welding iron plates, without pre-heating, is shown in the following table:—

Approximate thickness of plate joint		in. $\frac{3}{64}$	in. $\frac{3}{32}$	in. $\frac{3}{32}$ to $\frac{1}{8}$	in. $\frac{1}{8}$ to $\frac{3}{16}$	in. $\frac{3}{16}$ to $\frac{9}{32}$	in. $\frac{9}{32}$ to $\frac{3}{8}$	in. $\frac{3}{8}$ to $\frac{1}{2}$	in. $\frac{1}{2}$ to $\frac{5}{8}$	in. $\frac{5}{8}$ to $\frac{3}{4}$
Approximate consumption of gas per hour	Oxygen	c. ft. 4·25	c. ft. 7·5	c. ft. 12·0	c. ft. 17·0	c. ft. 25·0	c. ft. 37 0	c. ft. 60 0	c. ft. 85·0	c. ft. 125·0
	Acetylene	c. ft. 2·5	c. ft. 4·5	c. ft. 7·0	c. ft. 10·0	c. ft. 15·0	c. ft. 22·0	c. ft. 35·0	c. ft. 50·0	c. ft. 75·0

The time required to make a welded joint of given length depends upon the skill of the workman and the character of the work; but in an average case a weld on plate of ⅛ inch thickness should be carried out at the rate of 14 feet per hour; if ⅜ inch thick, 6 feet per hour; and ½ inch thick, 4 feet. For plates above ¼ inch thick, pre-heating reduces the time and cost by 30 to 50 per cent.

During recent years great progress has been made in applying the oxy-acetylene flame to the welding of non-ferrous metals and alloys, such as aluminium, copper, brass, bronze, etc., and the process has proved particularly useful in the case of aluminium, which cannot easily be joined by other means. In connexion with the production of munitions of war oxy-acetylene welding has played a very important part, and thousands of workers of both sexes have acquired great proficiency in this class of work. Another important application of oxy-acetylene is in the cutting of iron or steel plates. Fletcher discovered, many years ago, that if an iron plate were heated by an oxy-coal gas flame, and the supply of oxygen largely increased, holes and slots could be burnt out of the plate. In a modern blowpipe, as used for cutting iron, an additional passage is provided for a separately-controlled jet of oxygen, which may be made to impinge on the work. This jet, for example, may issue from a central tube, whilst the gases used for the flame are fed into the surrounding annulus. By this arrangement the work is heated to the necessary temperature by the flame, and converted into fluid oxide by the oxygen issuing from the central tube. The oxygen used for cutting is at a higher pressure than when employed for welding, and blows away the fused oxide through the cut, so that the operation is continuous. As the flame is only required to keep the work hot, the proportion of acetylene to oxygen used is much less than in the case of welding. The distance between the cutting nozzle and plate is maintained at about ¼ inch, and the size of the flame and the pressure of the jet are varied according to the thickness of the work. With a plate 1 inch thick, and a nozzle pressure of 14 lb. per square inch, a cut 40 feet in length can be made in one hour, with an oxygen consumption of 90 cubic feet. For a plate 1 foot thick, 1,760 cubic feet of oxygen are needed to cut a length of 16 feet in one hour, with a nozzle

pressure of 55 lb. per square inch. Plate-cutting by this process has almost entirely replaced cutting by steel tools in the case of boiler and ship repairs, and is now firmly established as a workshop process. Apart from cases in which operations involving the oxy-acetylene flame are continuously carried out, outfits for incidental work may now be found in almost every engineering establishment, and their use is continually extending. A monthly publication, the *Acetylene and Welding Journal*, is now issued, devoted to this industry.

The Electric Arc.

Everyone is familiar with the result obtained when two rods of conducting material are touched and a powerful electric current passed through them, when the rods may be drawn apart for some distance and the current maintained through the vapourised material which fills the gap. The limit of temperature attainable is decided by the vapourising point of the conductor, and using carbon, a temperature of 3700° C. may be reached which exceeds that obtainable by any other means by 700°. The use of the electric arc in furnaces will be considered later, but its application to welding may be conveniently dealt with at the present stage. In early attempts an arc was struck with carbon electrodes in proximity to the work, and fed with iron, but in this form the process was only moderately successful. A later development consisted in the use of a single carbon rod, with which an arc was formed by connecting the work to the source of current, an iron rod being fed into the arc as before; and this method is still in use for manufacturing seamless steel drums and pipes. The latest type of arc-welding, due to Albrecht and Dantz, is effected by using the work as positive electrode, and an iron rod as negative. In practice the iron rod is about $\frac{1}{8}$ inch in diameter, and is coated with a flux, and the welder strikes an arc between this and the spot to be operated on, maintaining a distance of about $\frac{1}{4}$ inch between the rod and the work. A powerful current is used, and as the rod melts the metal is carried through the arc and deposited on the work, the joint being hammered from time to time whilst at a welding heat. This is continued until the requisite quantity has been deposited, and owing to the high temperature of the arc a complete union is secured. A skilful welder can thus make a joint in the roof of a boiler, the iron from the arc adhering to the work, and not, as might be expected, dropping down in a molten condition. Arc-welding is thus specially useful for awkward places which could not easily be got at by other appliances; and in addition welds may be made in heavy masses without pre-heating, owing to the high temperature of the arc. Arc-welding is now extensively used in connection with repairs to ships, being applied to filling in cracks in boilers, flues, tanks, wheels, etc., and for restoring the metal in holes caused by corrosion. Figs. 3 and 4 illustrate a repair to the end-plate of a marine boiler carried out by the British Arc Welding Company, Fig. 3 showing the crack, and Fig. 4 the finished weld. Portable generating sets are made which may be used when power mains of suitable voltage are not available, and in this manner arc-welding may be carried out on a ship lying in harbour. Large steamers frequently carry an outfit for effecting repairs whilst afloat. A further useful application of arc-welding is the

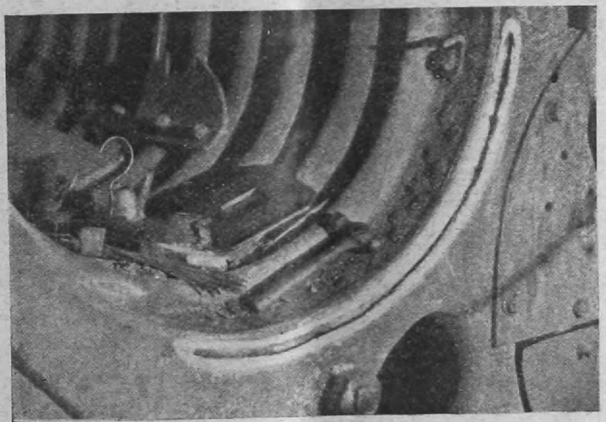

Fig. 3.—Crack in Boiler before Arc-welding.

filling of holes in tram rails, and the restoring of parts worn away by the abnormal friction at crossings. Fig. 5 shows the outfit provided for this purpose by the Equipment and Engineering Company, the head of the welder being covered by a hood in which tinted glasses are inserted to enable the progress of the work to be seen. The current in this case is taken from the tramway supply, being transformed to the correct voltage by means of a motor-generator. The saving effected in this case is manifest, as the alternative to the repair would be the renewal of the rail.

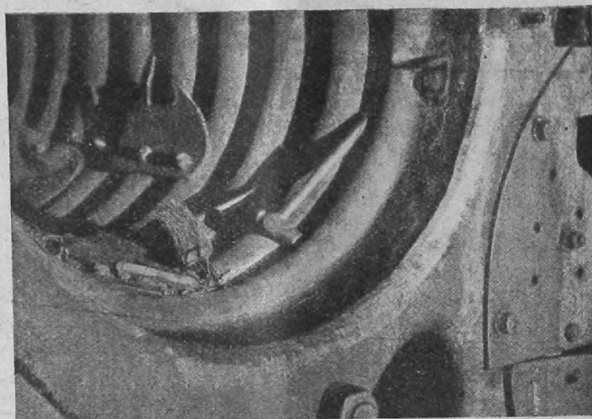

FIG. 4.—THE FINISHED WELD OF THE CRACK SHOWN IN FIG. 3.

Electric welding has for many years been applied to the joining of rods of iron or steel, as an alternative to fire welding. In this case the ends to be united are brought together, and a strong current passed through the contact. Heat is developed partly by arcing, and partly by the high resistance due to imperfect contact; and when a welding heat is attained the two portions are squeezed together and thus caused to unite. This method has been applied to large sections, for example, the jointing of consecutive rails on tramways, but is generally restricted to smaller classes of work. A method of joining wires to one another, or to plates of metal, has recently been experimented with in the United States, and is called "electro-percussive" welding. The wires are gripped in suitable jaws, with a small portion protruding, the lower jaw forming the base of a vertical frame down which the upper jaw may be dropped, the force of the impact being applied to the ends of the wires. The wires are connected to a charged battery of condensers, and when the upper jaw is allowed to fall a powerful spark is produced at the moment the wires come into contact; the heat generated, combined with the blow, causing the ends of the wires to weld together. If the lower wire be replaced by a plate of metal, the upper wire is welded to the place where it strikes. In this manner a tin wire may be welded to platinum, although their melting-points differ by more than 1500° C., and the process gives promise of application in many directions.

FIG. 5.—REPAIRING A TRAMLINE BY ARC-WELDING.

[A demonstration of oxy-acetylene welding and plate-cutting was given at the lecture by Captain D. Richardson, R.F.C.]

WATER-POWER IN THE BRITISH EMPIRE.

An interesting and important preliminary report of some thirty pages has been issued by the Water-power Committee of the Conjoint Board of Scientific Studies. The Committee, of which Sir Dugald

Clerk, K.B.E., F.R.S., is Chairman, and Professor A. H. Gibson, D.Sc., Secretary, was appointed "to report on what is at present being done to ascertain the amount and distribution of water-power in the British Empire." With this in view the Committee proceeded to collect all available relevant information. The report says:—

"The results have been both encouraging and disappointing. Encouraging because, in spite of the meagreness of the information regarding vast stretches of the Empire, sufficient data are available to show that its water-power resources are in the aggregate enormous; disappointing because, with the exception of Canada and New Zealand, Tasmania, New South Wales, and possibly South Africa, practically nothing has been or is being done on any systematic basis, to ascertain its true possibilities...

"To enable the Empire to recover, with any degree of rapidity, from the financial burden imposed by the war, it will be necessary to develop, in a much greater degree than heretofore, its latent resources. The wealth embodied in its mineral resources, its wheat areas, its forests, and the hundred products of its tropical dependencies, is almost incalculably great. But it must be realised that without an ample supply of cheap energy much of this wealth must always remain latent.

"Energy is required to enable the mineral ores to be won and refined. It is required for the adequate fertilisation of the land, as well as for the harvesting and transportation of its crops and products; and any scheme for the extensive development of the Empire's resources as a whole, must depend upon the preliminary development of its energy supplies."

The world's present power demand is estimated at, approximately, 120 million h.p., of which between 15 and 16 millions is developed from hydraulic resources. In respect to the latter, the United Kingdom is, with one exception—Russia—the most backward of twelve countries enumerated, our percentage being 8·3, against Germany's 43·4.

So far as the Dominions and Dependencies are concerned, it is fairly certain, the Committee says, that in Canada, India, New Guinea, and New Zealand alone there is a potential water horse-power of the order of 40 millions. Adding the resources of Africa (East, South and Central), Egypt, Ceylon, Australia (including Tasmania), British Guiana, Burma, the Malay States, and the British Isles it appears that in the aggregate the hydraulic resources of the Empire are extremely large and that they are as yet barely tapped.

The developments in engineering science in the past decade, and more particularly those in electro-chemical, electro-physical and electro-metallurgical processes, and in the possibility of high voltage electrical transmission, have removed some of the reasons for past neglect.

Special reference is made by the Committee to the utilisation of atmospheric nitrogen for the production of nitric acid and the manufacture of nitrates. The annual consumption of nitrogen in its various combinations is about 750,000 tons, and the need increases yearly.

"Four-fifths of this supply has been produced hitherto from natural nitrate deposits, but in view of the rapid depletion of these deposits, and of the diminution in the fertility of most of the great wheat and cotton-growing areas of the world, the production of artificial fertilisers by one or other system of nitrogen fixation must, in the near future, become a question of national importance.

"At the present time the world's consumption of fertilisers amounts to close upon 6,000,000 tons per annum, and this will probably be doubled within the next twenty years. To-day, the efficiency of the electrical production is low, amounting in the case of calcium nitrate to about three-quarters of a ton per e.h.p. year. By adopting the cyanamide process the consumption of energy may be cut down to about one-fourth, but even in this case the production of the equivalent of 12,000,000 tons of fertilisers per annum would require 4,000,000 continuous e.h.p.

"It is estimated that the 200,000,000 acres of arable land in Canada alone may ultimately require some 10,000,000 tons of nitrates per annum to maintain their fertility, and this in itself would necessitate the absorption of an appreciable portion of the whole hydraulic energy of the Dominion.

"When to these demands are added those of India, Australia and Africa, it is evident that the fertiliser demand of the Empire will in itself call for an enormous supply of energy."

After a general indication of the water-power possibilities of the separate parts of the Empire, the main conclusions drawn from the evidence available to the Committee are stated to be:—

"1. That the potential water-power of the Empire amounts in the aggregate to at least fifty to seventy million horse-power.

"2. That much of this is capable of immediate economic development.

"3. That except in Canada and New Zealand, and to a less extent in New South Wales and Tasmania, no systematic attempt has as yet been made by any Government Department to ascertain the true possibilities of the hydraulic resources of its territories, or to collect the relevant data.

"4. That the development of the Empire's natural resources is inseparably connected with that of its water-powers.

"5. That the development of such enormous possibilities should not be left to chance, but should be carried out under the guidance of some competent authority."

The Committee concludes its report by submitting the following recommendations:—

"1. That the British Government bring before the notice of the Indian Government, of the various Dominion Governments and of the Governing Bodies of the Crown Colonies, the necessity for a close systematic investigation of all reasonably promising water-powers, and of their economic possibilities.

"2. That the British Government take steps to ascertain whether the Governments concerned are prepared to undertake this work.

"3. That where such an inquiry is beyond the powers of any governing body, the British or Imperial Government place the work under the direct control of an 'Imperial Water Power Board' or 'Conservation Commission.'

"4. That the Government take steps to initiate the formation of such an 'Imperial Water Power Board' or 'Imperial Conservation Commission,' to include a representative from each of the Dominions and Dependencies.

"5. That this Board act in an advisory capacity.

"It should decide on the sequence of such investigation work as comes under its purview.

"It is suggested that all schemes for the development of which local resources are inadequate, should be submitted to the Board by the governments concerned, and that the Board should make recommendations on which the Imperial Government might take action.

"Such a Board would be able to take a broad and comprehensive view of the advantages to the Empire as a whole, attending the development of any given scheme, and would be able to form a reasonable decision as to the relative advantages of such different schemes as might be brought forward from different parts of the Empire.

"6. That since it is unlikely that private capital will be available for many years for hydraulic development on any large scale, powers should be obtained to enable the State to assist or to undertake such development if thought advisable.

"It is suggested that much might be done to attract private capital, if the State, after careful investigation, were to guarantee a suitable minimum interest on the necessary capital, sharing at the same time in any profits beyond the amount necessary to provide that interest. By this method of assistance private enterprise would be untrammelled, and the management of the concerns so assisted would remain in private hands."

CHINESE WOOD-OIL VARNISH.

The manufacture of kwang yu (literally "lustrous oil"), as practised by the Chinese, is very simple. T'ung yu, or wood-oil, is used as the base for this varnish, and two mineral substances, known as t'utzu and t'o-shen, are added. The process usually takes about two hours. The first step is to boil the wood-oil in large iron vats. Once the substance has begun to thicken, the mineral substances mentioned are added in proportions of one ounce of each for every catty of oil (catty = 1⅓ lb.).

As much of the wood-oil arrives on the local market containing a small percentage of water, it is necessary to use some substance which will free the oil of this adulterant. T'utzu, which is a ferruginous clay, serves this purpose by absorbing the water content. When the t'utzu is added, the liquid boils furiously, and at times, if the heat is too great, it bursts into flames. When this condition arises, a small percentage of linseed oil is added, and immediately forms a covering film, which smothers the flames.

T'o-shen, which local mineralogists state is native red lead, is added to the boiling oil at the same time as the t'utzu. This product is used to give the resulting liquid the proper colour, and to prevent it becoming cloudy or unequal in density. Before it is ready to be added to the wood-oil, it must be finely ground. This is accomplished by small hand crushers, which are usually made of stone.

It is impossible, writes the United States Vice-Consul at Hankow, to state the degree of heat that must be reached before the mineral substances are added, as the natives who manufacture the varnish have no set rules for the work. The point at which the liquid begins to thicken is considered the correct one, and from this point the boiling process is allowed to continue without further interruption until the oil finally reaches the consistency of varnish. This usually takes about two hours, although the amount of liquid in the vat and the size of the fire may materially alter the length of time required.

Kwang yu is used by the natives as a waterproofing substance for silks, pongees, etc., and also as an ornamental varnish when various colouring materials are added. It should not be confused, however, with the well-known lacquer varnish of China and Japan which, according to an authority on the subject, is gathered in its crude state from the *Rhus vernicifera* or che shu tree, and which is used for very different purposes.

THE "GO-TA-NI" BEAN.

Attention is drawn by the United States Consul at Mombasa to the production in East Africa of a new kind of bean, called the "go-ta-ni," which is described as yielding two crops per annum, with high percentage of albuminoids and oil, while the moisture is low. The owner of the estate at Changamwe, where the experiments have been made, calls the product a cross between the Madagascar butter bean and the *Canavalia ensiformis*. It is credited with a yield of 22 cwt. of dried marketable beans per acre during the 1916 season. The *Mombasa Times*, in an article on the subject, gives the following details:—

"The period for maturing is five months. The plant is a standard perennial, and attains an average height of 2 ft. 6 in. It is extremely hardy, being both a drought and insect resister. The foliage is dense, and if planted 1 ft. apart in drills, the rows being 3 ft. apart, it entirely prevents the growth of weeds. At this distance 63 lb. of seed will plant an acre. The seed readily

germinates. When 6 in. high the ground should be hoed, after which the plants require no attention until the crop comes off. Planted between young coco-nut palms, coffee, sisal, etc., they do away with at least two cleanings per year, while their foliage offers excellent shade and protection to the young plants.

"The pods attain a length of 14 to 16 in., and yield 14 to 16 perfect beans, which are ⅞ by ½ to ½ by ⅜ in. in two dimensions and ⅛ in. thick. They are white externally, the hilum being brown. The interior is a pale yellow, and they possess an agreeable flavour. On a sample sent to England £18 per ton was offered. This works out at £19 16*s.* per acre every six months. As the crop can be picked, thrashed and bagged on the land, it should prove one of the most profitable products grown in the Colony.

"The advantages of a perennial legume of this nature are manifold and cannot be overestimated. For planters it reduces the tremendous cost of cleaning to a minimum and brings the plantation into an almost immediate paying concern. It gives a good return in six months with very little outlay.

"There is nothing in the chemical analysis to indicate that the material is unfit for food; on the contrary, the beans should provide a nitrogenous food of a concentrated kind, the protein content being nearly equal to that of dried beef. No prussic acid has been detected in the macerated product, nevertheless, if the material has not been used before as food for human beings or animals, it would be advisable to ascertain by experiment that no poisonous substance is present."

CHINESE TRADE IN HUMAN HAIR AND HAIR-NETS.

From a report by the United States Consul-General at Shanghai, it appears that some of the hair used in hair-nets purchased by women in the United States has crossed the Pacific Ocean three times before reaching retail dealers. This results from the fact that a considerable part of millions of pounds of human hair exported from China finds its way back again, after preparation, for use in the manufacture of hair-nets—the so-called "invisible" nets worn by women over their hair. The hair-net business has become of great importance to the Province of Shantung, which now provides practically the entire supply of Europe and America, Germany and Austria formerly having had a monopoly of this trade. Nets were first made in Shantung under the direction of German firms.

According to the accepted trade explanation of the growth and development of this kind of business in China, it is understood that hair-nets were originally shipped by German parcel post to small villages in Germany, thence to Strassburg, the centre of the trade. The source of supply of those cheap nets was kept secret for three years.

In 1914 London began to buy direct from Chefoo, in Shantung, and for a while controlled the European and American trade. Later, France became active in the business. The market for hair-nets is now, however, being rapidly diverted to the United States.

On November 20th, 1911, after the downfall of the Manchu dynasty, a resolution was adopted in favour of the abolition of the queue. This was followed by the wholesale cutting of queues, not, however, to the extent generally imagined. In many parts of south and middle China the queue has practically disappeared; but the bulk of the populace in North China still wear it, and it is probable that many million queues will continue to be worn in China for an indefinite period.

The exportation of human hair from China, however, has grown greatly in importance during the last decade. Shipments for 1914 and 1915 fell far below those for the preceding four years, but this is probably attributable not to decreased demand but rather to the difficulty of procuring the hair.

Exports from China of human hair from 1910 to 1915 were as follows: 1910, 3,523,933 pounds; 1911, 2,583,867 pounds; 1912, 3,259,600 pounds; 1913, 3,667,867 pounds; 1914, 1,926,800 pounds; 1915, 1,919,200 pounds.

Estimating the weight of a Chinaman's queue to be 3 ounces (the reported average of 500 weighed queues), the number of queues required to make up the above shipments for six years would be more than 90,000,000, which is approximately half of the estimated male population of China, including queueless infants. As most of the older Chinese who still have queues will probably continue to wear them, and as new generations of even the most conservative will doubtless gradually drop the queue, there is likely to be increasing difficulty from year to year in obtaining sufficient human hair to meet the demands of the trade. However, dealers are not wholly dependent upon the queues of men for their supplies of hair.

Since 1912 and 1913 the queues of men have not been readily obtainable, and the hair-dealers are becoming more and more dependent upon the combings of women. Men who have dispensed with the queue in a good many instances allow their hair to grow to a length of 8 inches or more, and such lengths when cut are saved by the barber and sold to the small trader in hair. These small dealers make regular calls at barbers' shops and canvass the homes of the Chinese, collecting cuttings and combings and an occasional queue, all of which find their way finally to the central markets, where they are taken in hand by the wholesale dealers. Many poor women sacrifice their hair in times of stress, and large numbers of them during periods of flood and famine.

Hair is prepared for export in some markets by tying it into bundles containing hair of approximately the same length. The lengths run from 8 to 36 inches. In other markets bundles are formed containing proportionate quantities of hair

of the various lengths. Most of the exports go to England, France, and the United States, where the hair is manufactured into switches, curls, bangs, wigs, etc., of such colour as may be desired. The process is a delicate one, requiring expert judgment. Generally and briefly, it consists of bleaching by peroxide, thinning by acid, and boiling in dye. As a result the hair becomes finer in texture and softer than it was originally, and incidentally cleaner and more sanitary, since any one of the processes is sterilising.

The hair of certain animals, such as the yak, goat, and others, is mixed by the manufacturer with human hair to a certain extent. The hair of a white yak's tail is particularly valuable, not only because of its length, but also because of its whiteness, which, mixed with other shades, produces the desired silvery effect.

WEED DESTRUCTION IN SUGAR-CANE FIELDS.

A process of destroying weeds in canefields has been recently devised and developed by Mr. C. F. Eckart, manager of a sugar company in Hawaii, with the result that less than one-half of the labour formerly required is needed on the treated areas to bring the cane to maturity. In addition to the large saving in labour, the increased yield of cane as a result of the treatment, it is estimated, averages ten tons per acre.

Mr. Eckart found that small unexpanded cane shoots were able to penetrate a suitable paper covering placed directly on the rows of stubble immediately after harvesting, whereas the weeds are unable to penetrate it. According to a report by the Correspondent at Honolulu of the United States Department of Commerce, the first step in this process is to "palepale," or free the rows of trash in the ordinary way, as soon after harvesting as possible. During this operation a point is made to cut off with the hoe any shoots which are in evidence in the cane row. The stubble rows are then fertilised, the fertiliser being distributed along the middle of the rows. Strips of tar or asphalt felt (weighing not more than 9 lb. per 100 square feet) are next placed longitudinally on the rows of stubble, so that they lie directly in surface contact with them in the form of a cover. If the field contains a fair number of stones or rocks which are conveniently at hand, these are placed along the edges of the paper strips to hold them down, and in addition the edges of the strips are also covered well with some of the dried cane leaves or trash lying in the adjacent spaces between the cane rows. It has been found that the trash is generally sufficient in itself to hold the papers in place against the tendency of the wind to lift them.

Owing to the spearlike and comparatively rigid nature of the young cane shoots, and the mechanical pressure they are able to exert when they come into contact with the paper covering, the latter is punctured and the shoots emerge. The weeds, with their relatively soft terminal points, are soon smothered out, or are dried up by the solar heat radiating from the underside of the covering.

Five or six weeks after the paper coverings have been applied, labourers pass along the cane rows, and with a knife cut longitudinal slits in the paper at such places as are under pressure from expanded shoots, these places being distinctly manifested by the tentlike elevations. The slitting is inexpensive, and costs about 35 cents. an acre in practice. At first these shoots are naturally quite etiolated, but they quickly turn green and take on a vigorous growth.

The right kind of paper must be used. Of the many papers that have been tried in this process, the best is a lightweight tar or asphalt felt. The common black sheathing felt, weighing 9 lb. to 100 square feet, is to be preferred above all others which have been tested. Possibly a lighter felt might prove even more suitable, since the 9 lb. paper is the lightest that has been tried.

The large gain in the growth of the cane in this process is due to the automatic eradication of weeds in the cane rows and to the pronounced mulching action of the paper covers. Being black and impregnated with such material as tar and asphalt, they absorb a large amount of heat, which they impart to the soil of the cane rows.

Mr. Eckart's company is contemplating the erection of an auxiliary paper-mill of sufficient size to meet the demands of the fields for paper mulches. The raw material for the manufacture of paper would be a part of the bagasse from the crushed cane, and the mulches could be turned out at comparatively small cost.

AN AMERICAN PORT IN FRANCE.

In an article, entitled "Le gigantesque effort de nos alliés en France," *Le petit niçois* gave an interesting account of the extensive harbour works now in course of construction "somewhere in France" by our Allies the Americans.

From this we learn that upwards of 2,000 acres of land, which less than a year ago was mostly marshes, is now being transformed, almost by magic, into a port of the most modern type, provided with up-to-date appliances and machinery for discharging the cargoes of vessels of the largest tonnage.

An army of about 12,000 men is engaged in the construction of the docks, quays, and warehouses. Already large vessels are daily discharging their cargoes of warlike stores of every description by means of electric cranes. The new dock is being dredged and extended so as to berth at the same time fifty or sixty ships of large tonnage. About 100 miles of railway sidings have been laid down, to connect the new port with the principal main lines in that part of France.

A hospital, to contain upwards of 20,000, is also being built, and no time is being lost to make this new port one of the best equipped in the world, with all that is necessary for the rapid discharge of military stores, as well as for the landing of troops and artillery.

RECENT TESTS OF CONCRETE COLUMNS.

Among the tests conducted recently by the United States Bureau of Standards as aids to the development of industrial methods were series relating to the construction of concrete columns and the production of insulating material.

Three tests were made of a special commercial insulating material to determine its pre-resisting properties. The material submitted by the manufacturers was intended for use in a number of instances to replace wood. The test specimens were about 18 in. by 18 in. and 6 in. thick. They were placed in a furnace as a panel, one of the larger faces being exposed to the heat of the furnace and the other to the atmosphere. Upon being heated to 950° in 30 minutes and held at that temperature for four hours, it was found that the temperature at a distance of 1½ in. from the heat-exposed surface was about 240° C. At a depth of 5½ in. from the heat-exposed surface 66° was the highest temperature recorded. One of the blocks after having been subjected to this heat for the period mentioned was quenched with water. The damage to the specimen that was quenched was found to be less than to an unquenched specimen. This is explained by the fact that the blocks contained considerable organic matter, which tended to be disintegrated by the heat transmitted very slowly from the heated surface, even after the flame was removed from it.

The series of tests of concrete columns was partly in the nature of an investigation and partly in the nature of routine testing. These were the first columns of their kind to be tested in the United States. The unique feature is a hollow cast-iron core. This is surrounded by concrete, reinforced with both spiral and vertical reinforcing. Such a column may be made very cheaply. It would appear that the load which these columns can sustain is considerably in excess of that which can be borne by the ordinary reinforced concrete column of an equivalent cross-section.

ENGINEERING NOTES.

The Inventor of the Locomotive Engine.—A London daily newspaper has been taken to task for referring to the invention of the locomotive as due to Stephenson. It was in 1808 that the first engine, drawing a load behind it, was put on the rails by Richard Trevithick, many years before the first public railway was begun, for they were slow in those days; but it must be admitted that there was a British war during the interval. Stephenson, by his "pushfulness" and the sensational introduction of the "Rocket," was only following the improvements which Trevithick and many others had made. The compound and superheater methods, and those of many others, had no more godfathers than had the Northumbrian mechanic.

The Wilson Bridge over the Rhone at Lyons.—On July 14th a handsome bridge over the Rhone was inaugurated. The construction commenced shortly before the outbreak of war, and was carried on, notwithstanding the disturbance to public works which the hostilities have entailed. The *Génie Civil* of July 13th publishes an illustrated and detailed account of the work, of which a summary only can be given here. The bridge is of four main masonry arch spans, externally treated in pairs, 42, 45, 49, and 45 metres respectively, and two approach spans of 7·50 and 11 metres, on an inclined grade. The length over all is 226·30 metres. The width between parapets is 20·10 metres, comprising a carriage-way of 11 and two footways of 4·55 metres each. The internal space between the masonry arches, which are of perforated design, is of cross steel girders, supporting a floor of reinforced concrete and wood-paving. In a subsequent issue of the same journal, M. A. Auric criticises the design as regards the cross girders, stating, in his opinion, that steel girders ought to have been replaced by reinforced concrete ones, and that, with this in view, a pair of carriage-ways, right and left, over the stone arches ought to have been provided, leaving the single footway in the centre, to be supported by the reinforced concrete cross girders.

Quebec Dry Dock.—This dock, said by the *Engineer* to be the largest in the world, was begun in 1914 and has just been completed. The length is 1,150 ft., the breadth 120 ft., and depth over high water 40 ft. It is divided into inner and outer compartments, 650 and 500 ft. respectively. Centrifugal pumps are used, and 63,000 gallons per minute pumped against a head of 25 ft.; 550-volt Curtis turbo-generators, using 2,550 kilowatts, are employed. The filling takes four and the emptying 2½ hours. It is a notable fact that this enterprise, as well as an important large bridge, already referred to, over the Rhone at Lyons, should have been begun and ended practically simultaneously in war time.

Coal in Algeria.—The recent discovery of a bed of anthracite coal of considerable extent near Bona, in Algeria, has, says the *Electrical Review*, attracted the attention of the French Government, which has now taken over the working of the coal beds. The anthracite is stated to be equal to the best Cardiff coal, and to be sold at a price not higher than 150 lire per ton. Exported to Italy, its price would be about 210 lire per ton, and the first consignment of 30,000 tons will be ready for shipment shortly. Many Italian electric undertakings have been compelled to suspend working in consequence of inability to obtain imported coal, and the present opportunity is hailed with much satisfaction.

Paper Pulp.—In the manufacture of wood pulp for paper there are two essentially different methods: one, the mechanical system, which is

comparatively simple, and, secondly, the chemical systems, which require greater skill and knowledge in the operating staff. The latter systems are largely employed in Scandinavia, while the Colonial and American pulping plants are worked on the mechanical system. The wood generally used in the manufacture of wood pulp by the mechanical process is white pine or poplar. The wood is cut into slabs of a convenient size, which are then pressed against the face of a millstone revolving at a high speed, while a flow of water conveys the fibres of wood away as they are separated. The chemical processes, known as the sulphate and sulphite systems, are much more elaborate, and the pulp produced is used in the manufacture of printing and writing paper of superior quality.

An Electric Precipitation Process for obtaining Potash.—According to the *Journal of Electricity*, this process has enabled the United States cement workers to obtain potash from the residue dust. In one case a year's trial, under practical operation, has ended in the rather astonishing result of a greater income from potash than from cement. Operating costs show conclusively that the process will be profitable at pre-war prices, and that a supply of potash for fertilisers as well as for ammunition is now assured.

Indian Portland Cement.—A report, issued by the Indian Government, of tests by Mr. Musgrave, Alipore, states that he finds that Indian Bundi and Katni cements, as at present manufactured, are equal to the best English brands, also that the same is true of Porbandar cement, except as regards its tensile strength, which is somewhat low. All these cements are sound, reliable, and suitable for every class of work. Imported cements are not infrequently found to have deteriorated during a voyage, and Indian cements offer advantages in this respect also. When the article has to be conveyed long distances by rail from the factory to the consumer, the freight charges add greatly to the cost, and for this reason it is desirable that cement factories should be distributed over the country as widely as possible.

GENERAL NOTES.

CONCRETE STANDARD AND FABRICATED SHIPS.—Lord Pirrie, Controller-General of Merchant Shipbuilding, in the course of a statement he made on August 8th, referred to the steps taken to secure the present marked acceleration in output. He continued: "We have recently begun the building in this country of small concrete ships. These ships are being constructed, for the most part, in large wooden moulds (technically known as 'shuttering'), into which the steel rods for reinforcement are placed, and the concrete is afterwards poured in. We have at present fifty-six concrete vessels actually under construction, and have made arrangements for numerous other vessels to follow. The advantages of standard ships are that repeat vessels can be constructed with greater ease, and all the machinery and auxiliary fittings for each type of ship are interchangeable. Twelve months ago the number of standard ships under construction was 26 per cent. of the total, and to-day this proportion has increased to 74 per cent. The fabricated ship carries the principle of 'standardisation' considerably further. This type of ship was originally designed for the national yards, but private shipbuilders have asked to be allowed to build them, and already we have eleven fabricated ships on the stocks in private yards, for which units are being used which were originally ordered for the national yards."

INDUSTRIAL OUTPUT.—According to a correspondent of *The Times*, the output of coal to-day is less per man than it was before the war. It is sixty tons per man less than it was thirty-five years ago, when machinery, tools, lights and ventilation were not to be compared with what they are now. Dr. H. M. Vernon, of Oxford, writing to the same journal, mentions that in one of a number of yards in our two chief shipbuilding centres visited by him the riveters engaged on a very large oil ship were found to put in 15 per cent. less rivets per hour than they did in 1913 when engaged on the same type of ship, and when working the same weekly hours. In another yard, where standard ships of moderate size have been built for many years past, the rate of riveting was accurately investigated from 1903 to 1906, and was found to remain nearly steady throughout this period, both in summer and winter. From July to December, 1917, however, riveting squads on the same type of ship put 28 per cent. less rivets per hour than in the previous period, and in January to March, 1918, they put in 31 per cent. less. The other workers had deteriorated less than the riveters, but the platers showed a 20 to 25 per cent. reduction of output.

BRITISH SUGAR INDUSTRY.—The West India Committee have been informed that the Government have decided to give to the signatories to the Brussels Sugar Convention the requisite six months' notice of their intention to resume complete liberty of action in respect of their policy with regard to sugar. When the British Government withdrew from the Brussels Sugar Convention in 1913, they gave a pledge to the signatories not to give a preference in the duties in the market of the United Kingdom to sugar from British Colonies, or to cane sugar over beet, without six months notice. The West India Committee have constantly urged that such notice should be given immediately in view of the desirability of taking steps to secure the development of the British sugar industry, and to render the British Empire self-supporting in respect of its sugar supply.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

HIGH TEMPERATURE PROCESSES AND PRODUCTS.

By Charles R. Darling, A.R.C.Sc.I., F.I.C.

Lecture II.—Delivered January 28th, 1918.

Thermit.

More than half a century ago attempts were made by various workers to utilise practically the reducing power of aluminium. In these early experiments mixtures of oxides and metallic aluminium were heated by external means until the reaction commenced, with the general result that the crucible was destroyed, and occasionally the furnace also, owing to the extreme violence with which the chemical action took place. It was not until early in the present century that a means was found to apply this property of aluminium to industrial purposes, the credit for which is due to Goldschmidt, who originated the plan of igniting the mixtures at a point, with the result that the reactions proceeded more slowly, and without destructive effects. Goldschmidt, taking advantage of the high temperature produced, applied mixtures of aluminium and oxide of iron to the purpose of welding; and also used other mixtures for the production of metals such as chromium and manganese. The name "thermit" was applied to such mixtures, and at the present time thermit processes are largely used for a variety of purposes.

The intensely high temperature produced when an oxide is reduced by aluminium is due to the large heat of formation of aluminium oxide, which for 1 gram-molecule is 393,000 calories. Ferric oxide (Fe_2O_3) is formed from 112 grams of iron with the evolution of 196,000 calories. Consequently, in the reaction

$$Al_2 + Fe_2O_3 = Al_2O_3 + 2Fe,$$

the surplus heat of formation of aluminium oxide over iron oxide is liberated. The reaction proceeds so rapidly that practically the whole of this heat is utilised in raising the temperature of the products, radiation and conduction losses being small in the short time occupied. The actual temperature produced varies with the oxide used, but generally ranges from 2500° to 3000° C. As iron melts at 1500° C., and aluminium oxide at about 2000° C., both products of the reaction are fluid, and when contained in a crucible the iron sinks to the bottom, leaving the fluid alumina as a slag at the top. A similar result is obtained when other oxides are reduced.

One feature of thermit reductions is that the reaction does not commence below 1100° C., and hence a thermit mixture may be thrown on an ordinary fire without igniting. To start the combustion, a small quantity of ignition mixture, consisting of powdered aluminium and barium peroxide, is placed on the top of the thermit and lighted with a match, the temperature thus generated sufficing to commence the burning of the thermit. When once started the reaction spreads rapidly through the mass.

The welding of iron and steel now constitutes one of the chief applications of thermit industrially, and in many cases this form of welding is preferable to any other. A common example is furnished by tramways, the consecutive rails of which are frequently welded together by thermit. In this case a suitable mould or frame, lined with a refractory material, is placed round the joint, and an arrangement is attached by means of which the two rails may be squeezed together when brought to the welding temperature. The thermit is contained in a crucible above the mould (Fig. 6), and is ignited in the usual way. When the reaction is complete, the crucible is tapped by lifting up an iron nail which closes the outlet at the

bottom, the head of the nail being protected from fusion by a layer of fire-sand, through which it passes when lifted. On coming into contact with the molten iron in the crucible the nail is instantly melted, and the charge descends into the mould. The quantity of the charge is so regulated that the molten iron does not rise above the hollow part of the rails, the top being covered by the liquid slag, which is hot enough to bring this part to the welding

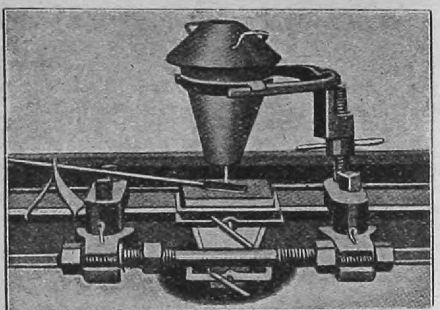

Fig. 6.—Outfit for Welding Rails by Thermit.

temperature. Pressure is now applied lengthwise, and the two rails become thoroughly united. On detaching the mould the alumina slag is broken away, and in the finished weld the under part of the rails and the hollow parts at the sides are united to the thermit iron, whilst the upper parts have been joined together by the pressure, as seen in Fig. 7. If thermit iron were attached to the top of the rails considerable labour would be required to smooth down the surface. In the few years immediately preceding the war, an average of 17,000 rail joints per annum were made in this manner in the United Kingdom. In effecting repairs of various kinds thermit welding has proved of great service. It has been successfully used in the case of large marine crank shafts, broken stern posts, etc., on ships, the quantity of thermit used being on occasion one ton or more. On locomotives it has been employed for the repair of cracked wheel centres, frames, horn blocks, etc.; and in general work for spur wheels, broken castings, and other purposes. Whenever possible, the broken part is preheated to a red heat before placing the mould in position and running in the thermit iron, it being thus ensured that the metal in the region of the crack shall become thoroughly fluid, and mingle with the thermit iron. In repairing breaks in cast-iron, 40 to 50 per cent. of steel punchings are added to the thermit, so as to lower the temperature of the reaction; and 15 to 20 per cent. may be added when welding mild steel if excessive heating is feared. Tests of thermit welds show that the union is complete, and that the strength of the joint is equal to that of the surrounding parts. The value of thermit for effecting repairs has been fully established during the present war, it having been used for emergency work of all kinds.

The thermit reaction has also been applied to the production of pure metals, and has proved of great value in cases where it is necessary to secure a product free from carbon. In the manufacture of special classes of steel in which manganese or chromium is used, it is desirable that these elements should be free from carbon, in order that the final carbon content may be regulated to any desired amount in the finished product. As prepared by furnace methods these metals always contain carbon to a greater or less extent, and hence for high-class steel the carbon-free metals produced by the thermit method are preferable—although more costly. The procedure is simply to mix the oxide of the metal to be extracted with the correct portion of aluminium, and to commence the reaction as in the case of iron thermit. When preparing 2 or 3 cwt. of metal only a portion of the charge is placed in the container at the commencement, and after ignition the remainder of the charge is added in portions until the container is full. The mass is then allowed to

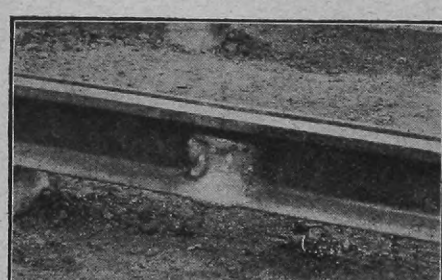

Fig. 7.—A Finished Thermit Weld on Tramway Rail.

cool, and is then removed and broken up to detach the metal from the alumina slag, the volume of which is three times that of the metal. Alloys may be prepared by using mixed oxides, and a large variety are made for industrial use. Amongst the metals and alloys so produced are chromium, manganese, cobalt, ferro-chromium, chromium-manganese, nickel-chromium, manganese-copper, and ferro-titanium, a total of thirty different products being on the market.

Before the war the thermit industry was in German hands, and it is a matter for congratulation that the present British proprietors have been able to reproduce practically all the compositions which previously were imported. This is an excellent example of the value of research in applied science.

No satisfactory use has yet been found for the alumina slag resulting from thermit reactions, although attempts have been made to utilise it for the manufacture of refractory crucibles, and for abrasive purposes. The material has qualities which fit it for either of these uses, but as it is inferior in these respects to other substances on the market, alumina slag cannot be profitably used at present.

The use of thermit in warfare is familiar to most people, as many incendiary bombs depend upon it for their action. The striking of the bomb brings about the ignition of the thermit, which, owing to the high temperature produced, is well adapted to the purpose intended. There are, in addition, a number of other military uses of thermit, the details of which cannot be given at the present juncture.

Metallic calcium has been used by F. M. Perkin and others instead of aluminium, and produces a similar thermit reaction. Commercially, calcium thermit has been restricted to the production of calcium silicide and a few other substances.

The Electric Furnace.

The employment of electric heating for large-scale operations has extended rapidly during recent years, particularly in localities where water-power is abundant, and electricity can be produced cheaply. Thus in Norway important industries have arisen, such as the manufacture of calcium carbide and the fixation of atmospheric nitrogen; and similarly the harnessing of Niagara has given rise to the production of artificial graphite, carborundum, and alundum by means of the electric furnace. In addition to the manufacture of substances only producible at high temperatures, the electric furnace has in many cases become a direct rival to fuel. In Sweden, for example, the output of electric furnaces in 1915 was as under :—

	Metric tons.
Iron	33,075
Ferro-silicon	11,819
Manganese ferro-silicon . .	2,328
Ferro-manganese	957
Zinc	8,588

Since then large developments have taken place, the most recent project being the erection of iron-smelting works at Porjus capable ultimately of an output of 100,000 tons per annum. Even in countries where fuel is cheap the use of electric furnaces is extending, as the superior value of the product often more than compensates for the extra cost of the heat generated. The rapid progress of the electric smelting furnace is indicated by the fact that in 1904 there were only four such furnaces in Europe and America, whereas the number in 1913 had arisen to 114; and so great has been the development during the war that more than seventy are now in use at Sheffield alone, in addition to others in various parts of England.

Electric furnaces may be divided into two types, the arc and the resistance. In the former an arc is struck between two or more carbon electrodes, and the material to be treated passed between the electrodes, or placed below them on the hearth of the furnace. In the resistance type, the current is conveyed by granular coke or other form of carbon, which is thereby raised to an extremely high temperature. A third variety, not now used to any great extent, is the induction furnace, in which the charge of material, which must be a conductor, takes the place of the secondary winding of a transformer, and is heated by the induced current which passes through it. The forms taken by electric furnaces in practice vary greatly according to the nature of the product, and detailed descriptions will be reserved for consideration in connexion with the materials dealt with later.

The temperature attainable in the electric furnace is only restricted by the vapourising point of the substance operated on, which in the case of carbon is 3700° C., and for iron, 2450° C. It is not necessary, however, to reach these temperatures unless desired, as the current may be regulated for any lower degree in most operations. Alternating current, either single or three-phase, is generally used, owing to the easy regulation of voltage by means of transformers, and the absence of electrolysis. In cases where the action is electrolytic, as in the reduction of aluminium, direct current is necessary and therefore employed.

Electric Steel-smelting.

The rapid increase in the output of electric steel is due to several causes, chief amongst which are (1) the superior properties of the

product; (2) the possibility of producing steels according to a given formula without difficulty; (3) the greatly reduced loss from oxidation of light steel scrap fed into the mixture; and (4) which applies specially to Britain, the possibility of obtaining a cheap supply of energy in certain localities. When all these factors are taken into account, high-grade steel can be produced more economically by the electric furnace than by the aid of fuel.

One of the earliest forms of steel-smelting furnace was due to Héroult, who employed three-phase current. Three carbon electrodes, spaced 120° apart, were placed above the charge, and arcs struck between them, the heat from which melted the metal below. Owing to the rotating field produced by the three phases, the molten metal rotated horizontally, causing a certain amount of mixing of the charge, and the product was satisfactory. A more modern type of furnace, the Greaves-Etchells, is shown in Fig. 8. In this two upper electrodes are used, connected to two phases of the three-phase supply, the third phase being joined to an electrode beneath the hearth. This arrangement results in heating from below as well as above, and in consequence a circulation is set up in the molten metal which ensures a uniform composition throughout. The lining of the hearth is of dolomite; and special devices are used to keep the phase currents balanced. In the furnaces made by Electro-Metals, Limited, two-phase current is employed, produced by transformers from three-phase supply; a suitable means of balancing being provided, and the arrangement being such that the metal is heated from above and below, as in the Greaves-Etchells furnace.

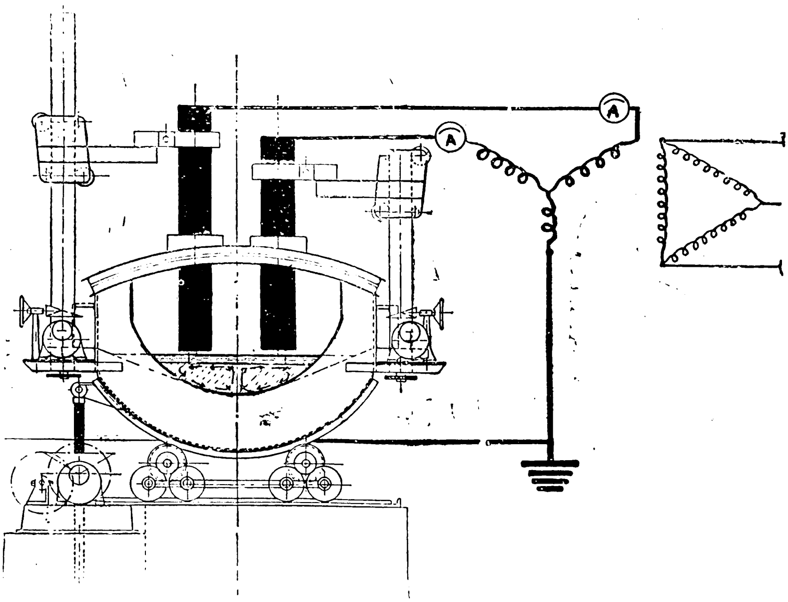

Fig. 8.—Greaves-Etchells Electric Steel Furnace.

The electric furnace has proved of great service in the manufacture of high-speed and special alloy steels, which it is capable of producing from cheap scrap and metal turnings, to which, after refining on the hearth of the furnace, the necessary portion of alloy is added. A product is then obtained of more uniform composition than that which results from melting in crucibles, and in addition it is possible to deal with larger quantities, meltings up to three tons of high-speed steel having proved successful. A further advantage of electric smelting is that steel castings of the best quality can be produced, which require no annealing, and can be easily machined. Such castings may be made from scrap and turnings, and owe their good qualities to the fact that the high temperature existing in the furnace renders the steel extremely fluid, which enables entangled slag and gases to rise to the surface. Furnaces of thirty tons' capacity have been constructed, and this is considered by some authorities to be the upper limit of economic size. One of the chief drawbacks at present is the rapid deterioration of the refractory lining; but this trouble will no doubt be overcome

by the production of durable refractories by electric furnace methods. In the event of one or more of the super-power stations proposed by the Coal Conservation Committee being erected near London, it is quite possible that the metropolis may become an important centre of the steel-refining industry.

In addition to steel, alloys such as ferro-silicon, ferro-chrome, and ferro-tungsten are manufactured in the electric furnace, being used subsequently for making alloy steel. Generally speaking, the alloys made in this way are not so pure as when produced by the "thermit" process, but are still sufficiently good for most purposes.

Fixation of Atmospheric Nitrogen.

The necessity of securing a source of nitrates to replace the supplies now obtained from South America, which sooner or later must become exhausted, has been recognised by all civilised nations, and the problem of oxidising atmospheric nitrogen on the large scale has been made the subject of investigation in most countries. Under peace conditions, the chief value of nitrates is for fertilising purposes; but during the present war immense quantities of nitric acid are needed for the manufacture of explosives. Several methods have been developed, some of which involve high-temperature reactions, and others (which depend upon the production of ammonia and its subsequent oxidation by catalytic means) in which only relatively low temperatures are employed. The former only will be dealt with as coming within the scope of the present lectures; but it may be stated that in all probability the low-temperature methods will prove the more economical.

Direct oxidation of the nitrogen in the atmosphere may be effected by the electric arc, and several types of furnace have been designed for the production of nitric acid by this means. When air is passed through the arc a quantity of nitric oxide is formed, which, in contact with cold air, combines with a further amount of oxygen to form nitrogen peroxide, NO_2. On dissolving this gas in water a mixture of nitric and nitrous acids is obtained, which may, if desired, be converted into salts by neutralisation. The efficiency of the process is restricted by the fact that if the nitric oxide exceed a certain concentration, it is decomposed by the arc; and Nernst has calculated that at 3000° C. the amount of NO in atmospheric air cannot exceed 5 per cent. for this reason. Hence in furnaces for this process provision must be made to remove the nitric oxide from the arc as rapidly as possible, and most early attempts failed owing to the absence of a satisfactory means of securing this end. The first successful apparatus was devised by Birkeland and Eyde in 1903, and consisted of a space lined with firebrick, into which copper electrodes, cooled by water, were inserted. The furnace was placed in the field of an electro-magnet, the lines of force of which passed at right angles to the plane of the furnace. On striking an arc between the electrodes by means of an alternating current, the arc was caused to rise and fall successively, being extinguished at the top and bottom of its path, and re-struck between the electrodes about 700 times per second. As a result of this continuous movement of the arc, the nitric oxide formed underwent the minimum of decomposition; and the air passing out of the furnace contained sufficient quantities of this gas to render the process commercially successful. A factory was erected at Nottoden, in Norway, working on these lines, which has remained in operation up to the present time; and numerous installations of the Birkeland-Eyde process have since been established in other countries. When properly worked, the process is capable of yielding 500 kilogrammes of nitric acid per kilowatt-year.

In the apparatus used by the Badische Anilin & Soda-Fabrik, a long arc is struck between electrodes inserted in the ends of a cylindrical tube, and pre-heated air is passed along the length of the arc for a certain distance, sufficient to ensure the production of the maximum amount of nitric oxide. A spiral motion is imparted to the entering air by suitable devices. This furnace has given good results, and has been used specially for the manufacture of sodium nitrite, which is used in the production of azo dyes. By allowing only a part of the NO to oxidise to NO_2, so that equal quantities of each are present in the treated air, sodium nitrite is formed directly by absorbing the mixed gases in soda. Many other forms of furnaces for the arc-fixation of atmospheric nitrogen have been devised, which, owing to considerations of time, cannot be dealt with in the present lecture.

Two other chief methods of nitrogen fixation, involving high-temperature processes, have been introduced; the Serpek process, in which aluminium nitride is first formed, and from which ammonia is obtained by treatment with

water; and the cyanamid process, in which nitrogen is passed over heated calcium carbide, yielding the compound $CaCN_2$, from which ammonia may be obtained by treatment with steam. In each case the ammonia produced may be converted by catalytic means into nitric acid. The Serpek process depends upon the reaction

$$Al_2O_3 + 3C + N_2 = 2AlN + 3CO$$

which is highly endothermic, and only commences at 1500° C. To ensure success the reacting temperature must be 1800° or 1900° C., and this is attained partly by fuel heating, and finally by an electric resistance furnace. Before the war, the Serpek process was being tested on a large scale in France, but it is not possible at present to state the final conclusions arrived at. The heat absorbed in the reaction is 213,220 kilo-calories or 248 kilowatt hours for 82 kilogrammes of aluminium nitride, or $\frac{1}{3}$ kw. year per ton.

Further reference will be made to cyanamid under the heading of calcium carbide.

Calcium Carbide.

When a mixture of carbon and lime is heated in an electric furnace, a reaction takes place which results in the formation of calcium carbide, according to the equation—

$$CaO + 3C = CaC_2 + CO.$$

The carbon is used in the form of coal or coke, and the purity of the carbide produced depends upon the quantity and nature of the ash in the coal or coke, and upon the foreign matter present in the lime. Anthracite coal, containing not more than 5 per cent. of ash, or a good coke of ash content not exceeding 6 per cent., should be used to produce a high-class carbide, the best qualities of both being obtained in South Wales. When carbide is used for making acetylene, the raw materials should be as free as possible from sulphur and phosphorus, as a part of these substances appears in the acetylene, and they are objectionable when the gas is used either for welding or lighting. A coal or coke containing not more than 1 per cent. of sulphur and ·04 per cent. of phosphorus, and a limestone in which the phosphorus is not more than ·01 cent., would be satisfactory in this respect. Of mineral impurities incidental to lime, magnesia to the extent of 1 per cent., silica 2 per cent., and traces of alumina may be permitted without detriment to the carbide produced.

The furnaces used are either of the single-phase type, in which the current is led through a vertical electrode to the mixture, passing out through an electrode at the bottom of the furnace; or three-phase, usually arranged with three vertical electrodes between which the current passes, and beneath each of which the carbide collects. Carbon electrodes are used, and the voltage employed in different cases varies between 100 and 30. Provision is made for tapping off the molten carbide, which is packed and sold under the rules of the British Acetylene Association. The pre-war consumption of carbide in this country was about 30,000 tons, of which all but about 2000 tons was imported. The small quantity made at home came from the works of the British Carbide Products, Ltd., at Thornhill, where power was obtained from the Yorkshire Power Company. The demand for carbide for various purposes has greatly increased during the war, and the works of the company named have now been removed to Clayton, near Manchester, where furnaces have been installed capable of turning out 15,000 tons per annum, power being taken from the Manchester Corporation. The cost of production is much greater than in Norway, where water-power is used, but this consideration is overborne under present conditions by the necessity of securing adequate quantities of carbide for welding, and for certain military purposes.

At first the use of carbide was restricted to the production of acetylene for lighting and welding, but during recent years two new applications have added greatly to its importance. One of these is the fixation of atmospheric nitrogen, and the other the synthetic production of alcohol and acetone. In the former process, nitrogen obtained from liquid air is passed over the heated carbide, forming cyanamid, $CaCN_2$. This substance may be applied directly to land as a fertiliser, in place of other nitrogenous manures, and is now extensively used for this purpose. When acted on with steam, cyanamid is decomposed, yielding ammonia, which may be converted into ammonium salts or oxidised to nitric acid by catalysts. Methods of producing alcohol by synthesis, using acetylene as the starting-point, have been devised, and may prove of great importance. It is stated that the quantity of carbide used in Germany for these secondary purposes rose from 8,000 tons in 1914 to 300,000 tons in 1917. It is not easy to predict the extent to which these processes will develop, under normal conditions, in competition with rival methods; but there appears to be good

reason to believe that the demand for carbide will continue for these purposes after the war. Whether the manufacture of carbide in Britain will become a large and profitable industry depends upon the success or otherwise of schemes for producing cheap electrical power.

Carborundum and Allied Substances.

The history of carborundum furnishes one of the romances of science, and shows how a small laboratory experiment may result in the establishment of a large and prosperous industry. Moissan, in his early experiments, observed the action of carbon on silicon, but did not develop his discovery. Working independently, Dr. E. G. Acheson, in America, found that, on subjecting coal and sand to a powerful electric current, crystals of an intensely hard material were formed. He produced a quantity of these crystals and had them tested for the grinding of gems, with such satisfactory results that the material was marketed, and sold to jewellers first at 40 cents per carat, and later at 20 cents, or £175,000 per ton. The production of four ounces per day exceeded the demand, and as a fresh outlet the substance, under the name of carborundum, was sold for valve grinding at £2 per pound. The demand grew, and to meet it furnaces using 135 E.H.P., and producing 45 tons per annum, were installed, the price being dropped to 2*s.* per pound. In 1894 the Carborundum Company entered into a contract with the Niagara Falls Power Company, to use 1000 E.H.P., and in 1895 production commenced at the new plant. The applications were extended by the production of abrasive wheels as a rival to emery, over which carborundum showed a marked superiority for most purposes. Later, papers and cloths coated with carborundum were produced, and as the result of continuous progress the output exceeded 5,000 tons per annum before the war, and has since greatly increased. Carborundum has now become an essential material in modern industrial practice, and has greatly simplified and shortened many operations.

The main reaction in the production of carborundum is shown by the equation:—

$$SiO_2 + 3C = SiC + 2CO.$$

Carborundum is therefore chemically silicon carbide. In the manufacture on the large scale, a mixture of sand, coke, and a quantity of common salt is placed in the electric furnace round a core of granular carbon, through which the current passes. The portion of the mixture adjacent to the core is converted into carborundum to a certain depth, beyond which a partial conversion only takes place, forming what is known as "fire-sand." The furnace is built of loose brickwork, and provided with vents for the carbon monoxide and vapours given off; and after cooling down the furnace is dismantled and the contents removed and separated. The mass of the carborundum consists of relatively small crystals, but frequently cavities are found filled with large, brilliant crystals, which are now a familiar sight in the windows of shops which deal in abrasive materials. The large crystals are not used in the manufacture of grindstones, but find an application in the hulling of rice, for ornamental signs, and for crystal detectors in wireless telegraphy. The finer crystalline mass forms the basis of carborundum abrasives. The chief sources of carborundum are the electric furnaces of the Carborundum Company at Niagara, and of the Norton Company, Chippawa, Ontario, the product of the latter company being designated by the trade name "Crystolon."

Silicon carbide as thus formed has a specific gravity of 3·12 to 3·20, and a wheel made of it weighs about 135 lb. per cubic foot. It cannot be fused, but if heated above 2250° C. decomposes. It is not acted on by pure oxygen below 1000° C., and is not attacked by boiling acids, even hydrofluoric. It is decomposed by fused alkalies, and is readily attacked by iron oxide, basic slag, and molten steel, which detracts from its use as a refractory. The most useful property of carborundum is its hardness, which approaches that of the diamond. The crystals have an irregular fracture, so that when broken in a grinding operation a sharp-cutting edge is always presented to the work. A grindstone made of it possesses a degree of toughness which fits it for the grinding of cast-iron, bronze, brass, copper, aluminium, marble, granite, slate, glass, and a number of other materials; but it is not sufficiently tough for successful use on steel, malleable iron, or materials of high tensile strength. In preparing the material for abrasive purposes, the mass taken from the furnace is broken up by crushers, and afterwards sifted through sieves of different mesh, producing grits of graded size, which are mixed with a bonding material and made into grindstones. Fine powders are also made for polishing purposes by subjecting the material which passes through the finest sieve to a process of settlement in water, the grading being decided by collecting the settled portion at definite intervals, ranging from one minute for the coarsest particles, and

100 minutes for the finest. Abrasive articles of carborundum are now manufactured in this country by the Carborundum Company, Ltd., at Manchester, the raw material being obtained from Niagara. Carborundum grindstones are now used in most engineering works, and in the small form are employed largely by dentists. In cutting stone mouldings, shaped grindstones are used against which the stone is pressed, the finished shape being rapidly imparted. In the form of slabs, carborundum is used for facing flat stone-work, etc.; and in the form of powder for lapping hard steel, and for polishing metals and stone. Carborundum cloth and paper are used largely for metalwork and woodwork in place of emery cloth or sand paper. Taken all round, carborundum is one of the most useful abrasives available, and merits the wide application it has received.

Carborundum sand, the outer zone product, is used for lining brass furnaces, silicate of soda being used as bond. It is also used, mixed with fireclay, as a furnace lining, as a moulding sand for aluminium, and for many refractory purposes.

A number of investigations have been made—chiefly in America—of the reactions of the carborundum furnace, and it has been found possible to produce several useful materials by modifying the working conditions. The reaction between silica and carbon commences at 1550° C., and the first product is a solid solution of SiC and SiO_2, known as "siloxicon." As the temperature rises, vapours of silicon are produced, which penetrate the carborundum already formed, and which play a part in the progress of the reaction. By raising the temperature to 1820° C., the complete conversion of the materials into silicon carbide may be effected, but the product is amorphous, and is known as "silfrax." At temperatures between 1820° and 2220° C. the crystalline variety, or ordinary carborundum, is produced; but if the temperature be still further increased decomposition occurs. In a normal run of a carborundum furnace the outer zones do not attain the highest temperature, and consist therefore of the partly-formed material, and contain siloxicon and silfrax. Both these bodies are good refractories; and silfrax has been made, by restricting the temperature as described, for manufacture into crucibles, pyrometer sheaths, and chemical ware, its resistance to acids being identical with that of carborundum. A number of other reactions occur in the carborundum furnace, one of which results in the formation of a material known as "fibrox," which appears as excessively fine threads, the diameter of which is only 0·6 micron, or just larger than the wave-length of yellow light. This remarkable material may be produced in greater quantity by the action of carbon dioxide on silicon, and is only a casual product of the carborundum furnace. A space of 1,000 cubic centimetres filled with fibrox packed by hand-pressure, contains only 2·5 to 3 grams of the solid; and hence it may be inferred that fibrox is an excellent heat insulator, as is fully borne out by experiment.

By using a lesser quantity of carbon, the element silicon may be prepared in large quantities in the electric furnace, the reaction being—

$$SiO_2 + 2C = Si + 2CO.$$

The formation of silicon was first noted in the carborundum furnace, in which small quantities may be found; and this led to the production of silicon as the primary substance, when desired, by reducing the proportion of carbon as shown. The element silicon thus became available in bulk, whereas previously it was more or less a laboratory curiosity. Silicon does not oxidise below 1200° C., and is useful as a resistance material for electricity, particularly when strong currents are used which make the resistor very hot. Its specific resistance is about three times that of carbon. When silicon powder is mixed with chlorate of potash, a powerful explosive is produced; and when mixed with some metallic oxides and ignited, a "thermit" reaction ensues, resulting in the reduction of the metal. This reaction, however, is weaker than when aluminium is used, the heat of formation of 1 molecule of SiO_2 being only 219,000 calories, compared with 393,000 for Al_2O_3. There is little doubt that silicon will find applications in many directions in the future, one promising line being the preparation of hydrogen on the large scale by acting on silicon with caustic soda.

[Samples of thermit welds and of pure metals prepared by the thermit reaction were exhibited by Thermit, Ltd., and specimens of carborundum abrasive appliances by the Carborundum Company, Ltd.]

OIL-YIELDING PLANTS IN INDO-CHINA.

M. Brenier, Director of the Chamber of Commerce of Marseilles, gives, in *Comptes Rendus des Séances de l'Académie d'Agriculture de France*, some interesting facts concerning the resources of Indo-China in oil-yielding plants.

From 1912 Germany imported 1,425,000 tons of oil-yielding seeds, whereas France, the chief importing country up to that date, only imported 1,219,000 tons in 1913, and England about one million tons. As the English oil mills increased their producing capacity by 25 per cent., importations into England rose to 1,700,000 tons in 1915, but fell in 1916 to 1,400,000 tons, still exceeding the French figures.

France has the greatest interest in finding in her colonies the raw materials necessary to the fat industry. From this point of view Indo-China offers resources of the greatest importance.

Among the plants grown M. Brenier mentions particularly the Chinese tallow tree (*Stillingia sebigera*), which grows in the north of Tonkin and supplies white vegetable tallow, and the wild varnish (*Rhus succedanea*), a lac tree cultivated in the Province of Putho, the seeds of which supply Japan with green vegetable tallow.

Amongst other trees capable of supplying raw material, though in small quantities only, may be mentioned: Mast-wood (*Calophyllum Inophyllum*), in Cochin-China; a species of Mahua (*Bassia* sp.) in North Annam; *Camellia drupifera*, in the same district and in Tonkin; *Garcinia tonkinensis*, a native of Indo-China; soap-nut (*Sapindus Mukerosei*).

"Abrasin" (*Aleurites montana* or *A. Jordii*) should also be mentioned on account of the drying properties of its oil, which is superior to that of linseed, and because it is well adapted to village plantations in Central Tonkin.

The most interesting cultivated plants are—the cotton plant, hevea, soya bean, castor oil-plant, sesame, peanut, and coconut.

The cotton plant is cultivated in Indo-China in the north of Annam and in the Province of Thanh Hoa, where the large population supplies abundant labour for the harvest. Large cotton-fields are situated at Cambodge, on the banks of the Kompong-Cham. Their produce, from 3,000 to 5,000 tons according to the year, is bought by Japan. The Lancashire mills use 500,000 bales of this cotton, which the British have introduced into India. Cotton seeds have a high value in oil yield, and when this plant is cultivated more largely at Cambodge French buyers will be able to obtain large quantities of seed.

Five million hevea plants have been put down. The Imperial Institute pointed out long ago the value of the drying properties of hevea-seed oil. The ratio of the yield in kernels to seed is 50 per cent., and the yield of oil from the kernels is 42 per cent. (laboratory tests). This produce is a secondary resource which should not be ignored.

The oil yield of the Cambodge soya bean is superior to that of Manchurian soya, although it does not exceed 18 per cent. The castor-oil plant is of great interest in Indo-China. It is chiefly cultivated in Tonkin, and is exported to Hong Kong and the Far East. In laboratory experiments, 42 per cent. of oil has been obtained, but by the European methods used in the few small mills of the country only 35 per cent. is obtained. Castor oil is much in demand at the present time as a lubricant. The value of the cakes used as manure is well known. Analysis made at Saigon showed the presence of 4·75 per cent. of nitrogen and 2·25 per cent. of potassium.

Sesame is cultivated in Tonkin and Annam, and might well be grown in Cambodge and Cochin-China. It gives a very high oil yield, sometimes as much as 50 per cent. Analysis proves the oil yield of Tonkin sesame to be very remarkable. The pure cultivation of sesame in Tonkin gives a yield of 9¼ cwt. per acre, whereas in British India, where enormous quantities of sesame are exported, the yield from mixed cultivation is only from 4 cwt. to 4½ cwt. per acre. From 1899 to 1903 the maximum annual importation of sesame into France rose to 139,000 tons.

In good years as much as 420,000 tons of peanuts are imported into Marseilles; this represents about a third of the French imports of fat. Although Senegal supplies 200,000 tons, this quantity does not nearly meet the commercial demands, and its further cultivation in other colonies is therefore most desirable. Light soil, indispensable to the cultivation of the peanut, is found in Tonkin, Central Annam, Cochin-China, and Cambodge. Experiments show the ratio of the shell to the whole seed to be equal to that of the best African varieties (32 to 24 per cent.). As the Annamite methods of cultivation are superior to those of the negroes, a higher yield is obtained than in West Africa. In Africa the yield is from 20 to 29 cwt., whereas in Indo-China it is as high as 39 cwt., or, in good soil, even 49 cwt. M. Brenier imported from Java a peanut which is very easily gathered on account of the grouping of the pods round the neck. This variety does very well in Indo-China, but appears to give a lower yield in oil than the ordinary peanut.

The coconut tree covers more than 24,711 acres. It is grown chiefly along the Annam coast, which, being subject to typhoons, is not the most favourable situation. The coconut grows along the south coast, and also in the interior of Cochin-China, where its cultivation is localised in the towns of Mytho and Bentre. The coast of the Gulf of Siam, outside the typhoon zone, appears to be the most favourable district for cultivating coconuts. The natives plant the trees much too close together, so that in Annam the yield of one tree does not exceed 23 to 25 nuts, whereas in plantations owned by Europeans, where the trees are farther apart, as many as 50 to 75 are obtained. The yield in copra and in "coir" (fibre obtained from the mesocarp) of the coconut trees of Indo-China competes closely with that of coconut trees in Malaya, Ceylon, the Indian Archipelago, and the Antilles. As desiccation causes a loss of 50 per cent., distinction must be made between the green kernel and the copra in estimating the yields. If copra is valued at £2 per 220 lb. (its actual value is

double that), the gross revenue from an average of 50 nuts per tree may be calculated at £10 per acre. If an average of 70 nuts per tree is taken, the revenue will be £14. The coconut tree bears fruit for fifty years. In the Malay Peninsula one acre of a European plantation is valued at about £25.

INDUSTRIES AFTER THE WAR.

In 1916 the Board of Trade appointed four Departmental Committees to consider respectively the position of the iron and steel, engineering, electrical, and textile trades after the war, especially in relation to international competition and to report what measures, if any, are necessary or desirable in order to safeguard that position. The chairmen of the several committees were: *Iron and Steel*—Mr. G. Scoby-Smith; *Engineering*—Sir Clarendon Golding Hyde; *Electrical*—the Hon. Sir Charles A. Parsons, K.C.B., F.R.S.; *Textile*—Sir Henry Birchenough, K.C.M.G. All the committees finished their work by the middle of the following year, but their reports were not presented to Parliament until towards the close of last Session. They have since been issued to the public.

I.—Iron and Steel.

The Iron and Steel Trades Committee say that the problem of which they have attempted to reach a solution is to give the nation industrial resources which in time of peace shall preserve the prosperity of Great Britain, and in time of war give her full command of resources adequate to the defence and safe-keeping of the Empire. The committee specially refer to the rapid development of these two industries, which they describe as one of the most striking features of the economic history of the nineteenth century, and to the revolution caused by the discovery of the Thomas (Basic Bessemer) process. It was only in or about 1880, when the Thomas process was applied to the open-hearth furnace, that basic steel attained comparative equality with acid steel, and not until ten years later that the Admiralty and Lloyd's permitted the former to be used in shipbuilding. The manufacture of steel in the electric furnace is still in its infancy, but the process is gradually extending for the manufacture of high-grade steel and for the production of castings of special quality, and there is every reason to anticipate that steel so produced from domestic raw materials will, to a great extent, replace the steel formerly manufactured from imported Swedish iron and steel in the specialised manufactures of the country. While as regards the ironfoundry industry there have been no "epoch-making discoveries," there is a record of steady progress in foundry practice and of improvement in the quality of the product as well as an advance in the scientific education of those engaged in the industry.

The scope of the inquiry being very wide, the committee treated the numerous subjects separately, and from time to time made interim reports to the President of the Board of Trade. These are reproduced in the general report, the names of the signatories, with or without reservation, being appended to each. The summary of recommendations is grouped under various headings. Altogether there are sixty-one recommendations. The first six deal with commercial reconstruction, and are as follows: (1) That all imports of manufactured or semi-manufactured products of iron and steel from present enemy countries be prohibited during the period of reconstruction; (2) that all ores and minerals necessary for the manufacture of iron and steel be admitted free, and all other materials necessary for the manufacture of iron and steel be admitted only in their natural or unworked state; (3) that no raw materials be sent to present enemy countries from British Dominions or Colonies, or from mineral or other resources under British control; (4) that British ships shall not carry raw materials or manufactured iron and steel from neutral ports to ports in present enemy countries or to neutral ports for ultimate despatch to enemy countries; (5) that careful Government consideration be given to the question as to whether the ships of present enemy countries shall be allowed to carry goods to or from ports in the British Empire, or to coal at any coaling station in the British Empire; (6) that licences be granted in cases where national interests demand the relaxation of the regulations recommended above, and that a fully representative committee of the iron and steel industries be appointed to regulate the issue of such licences where they directly affect the industries.

The other recommendations include the following: That an organisation be formed comprising users of iron ore, and others interested in and essential to the conduct of the trade, to undertake the import and distribution of foreign ores in Great Britain and acquire interests in ore properties abroad, and that such organisation should receive Government financial assistance if necessary; that no mining concessions within the Empire be granted to any alien individual or company without Government sanction, and that the Dominions be urged to adopt a similar policy; that an adequate economic survey be made of the natural resources of Great Britain and other parts of the Empire; that iron and steel manufacturers associate themselves for the purposes of export trade, and form common selling organisations by the extension and consolidation of associations which already exist; that an organisation—co-operative in character—be formed among British manufacturers for the purpose of obtaining adequate supplies of suitable iron ore; that a national selling organisation be formed for the purpose of marketing British iron and steel products in an efficient and economical manner, and that British iron and steel manufacturers be urged to form combinations for the purpose of laying down large and well-designed new units for cheap production upon modern lines.

Recommendations respecting labour relations, protection, royalties and wayleaves, means of transport, technical education, etc., follow.

Finally, general subsidiary questions are dealt with, and in this connection the committee recommend, *inter alia*, that where permission is given by H.M. Government for the raising of loans in the United Kingdom this permission be conditional upon the purchase of as much of the material required as possible in the United Kingdom, and that all purchases of iron or steel made by or for Government Departments, public bodies, railways, etc., within the United Kingdom shall be of British manufacture.

SYRUP OF GRAPES AS A SUBSTITUTE FOR SUGAR.

The great scarcity of sugar in the district of Turin, as well as in the entire Kingdom of Italy, and the Government prohibition of its use in wine-making processes, has effectually drawn attention, writes the United States Consul at Turin, to the sweetening methods which were employed during the economic crisis of 1790–1800, when it was found that syrup of grapes furnished a fairly satisfactory solution of the problem. The matter perhaps is of equal importance at present.

The experiments carried out at the period mentioned, although of great benefit, did not meet with all the success desired, on account of imperfect elimination of acids and the unpalatable character that the process of extraction imparted to the syrup. Although it is now recognised that syrup of grapes cannot take the place of sugar for general purposes, it is an excellent sweetening for jam, marmalade, etc., increasing their nutritive value.

For the extraction of the syrup of grapes it is of the utmost importance to use well-matured fruit, and alcoholic fermentation must not occur during the process. As it is difficult to ensure such conditions with the liquid in a state of repose, and as it is desirable to eliminate all solid particles and albuminous and pectic substances, it is necessary to use centrifugal force, by means of which 75 per cent. of the deleterious substances can be eliminated. It is also important to avoid any undue action of the press, which would tend to enrich the liquid at the expense of the extracted substances. A natural flow of juice should be sought, the liquid basis being contained in a receptacle furnished with a false perforated bottom. The liquid that issues from the channel of the apparatus is very sweet, and comes from the surface.

This operation must be well regulated, so that the action is effective both as to quality and quantity of the product. Any liquid which remains in the receptacle after the conclusion of the process of extraction may be fermented separately. The issuing liquor feeds the centrifugal machine continuously. Should the output of the latter diminish, the incoming flow of liquid should be arrested and the plate cleaned; in a few minutes the machine will again be ready to work. The liquid so obtained is poor in fermenting elements, and in order to ensure its preservation for several months, from 100 to 150 grammes of sulphate of potash per 100 hectolitres of liquid may be added; or the direct system of sulphurisation may be adopted, using sulphuric gas obtained from the combustion of sulphur. The latter method is considered to be most advantageous—at least, under present conditions, in view of the high price of potash. This process costs only about 1*d*. per hectolitre. By repeated trials it has been perfected, and apparatus has been brought out which avoids the necessity of the use of potash in wine-making processes.

PETITGRAIN OIL INDUSTRY OF PARAGUAY.

The chief article of direct export from Paraguay to the United States is oil of petitgrain, an extract obtained from the bitter orange leaves that are found abundantly in Paraguay. Exports of petitgrain oil invoiced at the American Consulate at Asuncion, writes the United States Consul, for exportation to the United States amounted to 23,040 lbs., valued at about £7,000, in 1915, and to 33,680 lbs., valued at about £12,000, in 1916. Previous to the war France was the principal market for the exports from Paraguay.

Oil of petitgrain is used as the basis of perfumes and perfumed toilet soaps. It requires 500 lbs. to 600 lbs. of leaves to produce a quart of the extract. The oil is extracted by packing the leaves into a barrel-like receptacle with perforations in the bottom, through which steam is passed. A pipe leading from the top of the receptacle conducts the steam, which also contains the extract in vapour form, to a condenser where the mixture is cooled and the oil appears on the top ready to be drained off. The product in this form, which is considered ready for market by some producers, has a distinctly oily odour. Some of the more important producers have a secret process of distillation that further refines the extract, leaving it with a perfume like that of Florida water. When tested by a densimeter, the specific gravity of the distilled extract is found to be about 28 or 30.

NOTES ON BOOKS.

THE BERNERS ESTATE. By John Slater. Unwin Bros. 1918.

This interesting "short history" of the estate to which the author is surveyor offers an example which the owners, or officials, of the other great London estates would do well to follow. The Bedford estate, for instance, though its history does not run nearly as far back as that of the property with which Mr. Slater is associated, occupies an area even richer in historical traditions, and it is known to possess a complete and carefully compiled record of all the changes and

alterations in the property since it first came into the possession of an ancestor of its present owner. There must exist, in the private records of the London estates, where these have, as no doubt they have, in most cases for legal purposes, been carefully preserved, a large amount of detailed information, which would be of value, if available, to students of London history. It is to be hoped, therefore, that Mr. Slater's little book will not long be the only one of its sort, and it may also be hoped that its successors may be as well and as carefully compiled, for it is full of interesting material.

Of all the London estates there is, it is understood, no other which can compete with the Berners estate as regards antiquity of record. The estate was purchased by Josias Berners in 1654, but the documents in the owner's possession enable its history to be traced back to 1546 "when it formed part of the old Leper Hospital of St. Giles, which probably acquired it by private bequest or gift in the reign of Edward I." (1272–1307), so that the history of the estate, so far as it can be said to have any history in these early days, may be said to be known from the end of the thirteenth century. After the dissolution of the hospital, the ground now forming the estate was granted by Henry VIII. to John Dudley, afterwards the Duke of Northumberland, who was beheaded for his attempt to put Lady Jane Grey on the throne. He sold it to Wymond Carew in 1596, and the deed of sale, with all the subsequent deeds effecting transfers of the property, is now in the keeping of the office of the estate. The record therefore is continuous and complete for six centuries. An interesting description is given by Mr. Slater of the surroundings of the property when it was bought by Josias Berners in 1654. It was then a country farm, with fields running down to what was then Tyburn Road, and is now Oxford Street, a country road with no houses upon it except a few taverns, the resort of footpads and other bad characters. Further west was a bridge over the Tyburn, then one of the chief sources of London water-supply, with Tyburn Tree a little further along, either, as Mr. Slater says, near where the Marble Arch now stands, or on the other side of the road. The estate itself, whatever alterations it has undergone, covers the same area in 1918 that it covered in 1654. Its Oxford Street frontage, about 320 yards, extends from Wells Street to Perry's Place, and the property runs back to the Middlesex Hospital. It also comprises a long strip along the southern side of Cleveland Street. The modern development of the estate was started about 1750, when the existing streets were laid out, Berners Street itself dating from 1763. At the end of the eighteenth century and the beginning of the nineteenth it was a fashionable residential district, where many well-known persons lived. Some of these are mentioned by Mr. Slater, and to those whose names he records may be added, on the authority of the late Mr. H. B. Wheatley, some other well-known Berners Street residents. Opie, the celebrated artist, and J. Lonsdale, the portrait painter, both lived at No. 8; Sir Robert Smirke, R.A., the architect, No. 13; Henry Bone, R.A., painter in enamel, No. 15, where he died in 1834; Dr. Robert Gooch, the well-known physician, No. 19; W. Shield, the composer, No. 16; James Bartleman, bass singer, No. 45; and Richard Warrington, actor, No. 29.

It may also be mentioned that Sir Thomas Chambers himself built his house, No. 53, and that it was for many years the home of the Medical and Chirurgical Society. Theodore Hook's famous Berners Street hoax was perhaps considered too trivial an affair to deserve record in a serious history, though it formed the subject of an article in the *Quarterly Review*. James Barry, it may be added, not only lived in Castle Street, but he died there.

GENERAL NOTES.

Big Harbour Scheme for Naples.—The largest dock in the Mediterranean is to be constructed near Naples. According to the *Giornale d'Italia* the decree has been signed conceding to that city the right of carrying on the necessary constructional works in the harbour of Baia. Among the minor undertakings will be the transformation of Lake Averno into a marine basin, with a large industrial zone adjoining the construction of an outer harbour in the Gulf of Baia and of a communicating canal between this harbour and the lake, with a quay provided with all the latest appliances. The total cost is not to exceed L.50 mill., to which the State will contribute L.22 mill. in fifty annual instalments. All the works are to be commenced at latest within six months after the declaration of peace, and to be finished within six years. After sixty years all the works are to become the property of the State without further payment.

The Oldest British Industry.—It appears that one effect of the war has been to put an end to what is certainly the oldest British industry, that of the flint "knappers" of Brandon in Suffolk. There is every reason to believe that it has been carried on from neolithic times, and how many thousands of years this was before the Roman invasion of Britain, not even geologists are in a position to decide. To say that it has been carried on continuously would be too much. It may have been interrupted by prehistoric warfare, though, as in those days it must have been the principal munitions factory for the locality, such interruptions were improbable. It is the lack of labour, not the absence of demand for gun-flints and "strike-a-lights," that has stopped work at Brandon. There was still, before the war, a trade in gun-flints to Africa and South America. Till the work was stopped it was carried on precisely in the same way as in prehistoric times. The flints were quarried by sinking short shafts, and when the supply from each little shaft was

exhausted, it was filled up, and a new one started. No mechanical power, not even a windlass, was used in bringing the flints "to bank." The men carried them on their heads, ascending by means of steps cut in the sides of the shaft, just as their prehistoric predecessors did. The splitting and chipping of the flints was effected in the ancient methods, indeed the devices of the modern knappers have thrown a good deal of light on the methods by which the old flint implements were made. Fortunately before the industry became extinct, it found an admirable historian in Mr. S. B. T. Skertchley, who described it fully and with exhaustive detail in one of the *Memoirs of the Geological Survey* in 1879. Whether the industry will ever be renewed remains to be seen. Probably it will be difficult to recover the traditional skill handed down in the families of knappers, and the skill required is very considerable. Once lost, it is not likely to be recovered.

War-time Boots for Civilians.—In an article in the *Board of Trade Journal* on "The Control of Leather," reference is made to the steps that were taken in view of the possibility of a serious shortage of civilian footwear, especially for the poorer classes. It was decided that the War Office should intervene to the extent of controlling production by requiring manufacturers to produce certain quantities of boots for the general working-class population, and that the prices of these boots to the public should have some definite relationship to the cost of production. Sixteen committees were appointed throughout the country, and they were asked to select a range of the boots that could most economically be made in their respective areas. Over 200 samples were submitted, but since the admission of so great a variety would have rendered standardisation ineffective, the number was reduced, and it now stands at about 80. The prices finally fixed allow a profit of 5 per cent. to the average manufacturer, and the retail trade agreed to handle the boots at an addition of 33⅓ per cent. on the manufacturers' prices. If the services of a factor are employed his remuneration comes out of the 33⅓ per cent. Manufacturers have been instructed to devote one third of their non-military capacity to the production of war-time boots, and this has priority over all other work except Government contracts.

Transport Facilities.—The House of Commons, on August 6th, ordered that a Select Committee be appointed for the purpose of considering what steps, if any, it is desirable to take to develop and improve the internal facilities for transport within the United Kingdom; to secure effective supervision and co-ordination; and to ensure that such developments and improvements shall be adequate and suitable to meet the national requirements. The Committee, which numbers fifteen, has been granted power to send for persons, papers and records, and to appoint from outside such additional persons as it may think fit to serve on any sub-committee it may decide to establish.

THE LIBRARY.

The following books have been presented to the Library since the last announcement. Except where otherwise stated they have been presented by the publishers:—

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Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, SEPTEMBER 6, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

HIGH TEMPERATURE PROCESSES AND PRODUCTS.

By Charles R. Darling, A.R.C.Sc.I., F.I.C.

Lecture III.—Delivered February 4th, 1918.

Alundum and Aloxite.

The fusion of the mineral bauxite, an impure form of oxide of aluminium, results in the production of a crystalline material inferior in hardness to carborundum, but superior in strength. In grinding steel, or materials of high tensile strength, an abrasive material is needed which will not break under the pressure which must be applied, and in such cases it is found that grindstones made from fused bauxite are quite satisfactory, whilst carborundum wears away too quickly owing to the breaking of the crystals. Fused bauxite is manufactured into grindstones by the Norton Company in America under the name of "Alundum," and a similar product is marketed by the Carborundum Company of Manchester, which is termed "Aloxite."

The fusion of bauxite is effected by mixing the mineral with coke, and placing the mixture in a furnace provided with a carbon bed. Two vertical carbon electrodes pass into the mixture, and the current is conducted, in the first instance, by the coke. Above 1600° C., however, the bauxite becomes a conductor, and improves in conductivity as the temperature rises, finally melting at about 2000° C. When the mass is fused, any reduced iron from the iron oxide in the bauxite sinks to the bottom, whilst any unburnt coke floats to the top; and after cooling the interior of the mass consists of crystalline alumina, containing a greater or less quantity of oxide of iron, according to the quality of bauxite used. The mass is broken up in crushers, and separated into grits of varying fineness by passing through sifters of different mesh. In making grindstones of any desired grade, the grit chosen is bonded either with shellac, rubber, silicate of soda, or, by firing, with a vitreous clay bond; the bond used being decided by the nature of the work to be performed by the stone. As an abrasive for steel, fused bauxite is unrivalled, and together with carborundum has made possible the introduction of grinding machinery which for many purposes is preferable to steel cutting-tools, producing a better finish in a shorter time. The speed of revolution of the stone, in the average case, is such that the velocity at the circumference is 5,000 to 6,000 feet per minute. A vitrified wheel weighs approximately 144 pounds per cubic foot.

The best bauxite for the manufacture of abrasive material is found in the south of France, and the furnaces of the Carborundum Company are located near the mines at Sarrancolin, in the foothills of the Pyrenees, power being obtained from a hydro-electric installation which develops about 8,000 horse-power. The furnace product is shipped to Manchester and worked up into grinding wheels at the Trafford Park works. The bauxite deposits of Antrim are unfortunately too variable in composition to be utilised for making abrasives, and have proved equally unsuitable for producing pure alumina for the manufacture of aluminium. A large quantity of the grinding wheels manufactured in America are made from French bauxite.

Whilst used primarily as an abrasive, fused bauxite may be made into an excellent refractory, and the alundum ware produced by the Norton Company is extensively used for the tubes of small resistance furnaces, crucibles, pyrometer sheaths, etc. In making articles of this kind, the powdered alundum is mixed with a suitable bond, and the object moulded from

the mixture and afterwards fired. The product so obtained has a low coefficient of expansion, and withstands sudden changes of temperature far better than porcelain, but not so well as silica. It is relatively a good conductor of heat, which property fits it for the purposes named; and its high melting-point—2050° C.—renders it suitable for work at temperatures which would cause fused silica to devitrify. It has the further advantage of being inert towards platinum at high temperatures, and is therefore suitable for platinum-wound resistance furnaces. Ordinary alundum is porous, and this property has been put to use for filtration purposes in laboratories, the liquid to be filtered being poured into a crucible, in the pores of which the finest particles of precipitate are retained. As the alundum is unattacked by most acids, solutions may be filtered which would destroy filter papers. Porosity, however, is a drawback in the case of a pyrometer sheath; and to overcome this the Norton Company have introduced a non-porous variety, which resists the entry of furnace gases even at high temperatures. In the form of various articles, alundum has now become firmly established as a useful laboratory material.

[Samples of laboratory ware made of alundum were exhibited by Messrs. Townson & Mercer; and of aloxite abrasives by the Carborundum Co., Ltd.]

Artificial Graphite.

Natural graphite, under the names "plumbago" and "black lead," has long been used in the arts for the manufacture of crucibles, lead pencils, and compositions for coating metals. As found, it is associated with minerals such as oxide of iron, silica, alumina and lime, which it is difficult entirely to remove. Moissan was one of the first to notice that ordinary amorphous carbon could be converted into graphite by the aid of intense heat; but the commercial production of artificial graphite was due to Dr. E. G. Acheson. On examining the products of the hottest zone of his carborundum furnace, Acheson noticed crystals of graphite, formed as pseudomorphs of carborundum. This observation led him to make experiments with a view to the production of graphite in quantity, which resulted in the invention of the graphite furnace in 1896. Works were established at Niagara, and at the present time the output of Acheson graphite is several thousand tons per annum. The process of manufacture consists in passing a powerful electric current through coke, anthracite coal, or carbon obtained from petroleum residues, producing a temperature of 3700° C., which suffices to convert ordinary carbon into graphite. The materials are placed in a loose-walled furnace, which can easily be dismantled to remove the products; and at the temperature employed most of the impurities volatilise and escape as vapours through vents in the walls. When the process is complete, carbon vapour begins to come off, giving a distinctive tint to the escaping fumes. When articles of definite shape are required, such as plates or rods, they are first formed into shape from a mixture of finely-divided carbon and pitch; then baked to carbonise the pitch, and subjected to the current in the furnace. The carbon is changed into graphite without the article losing its shape, and incidentally nearly all the impurities vaporize, leaving graphite of 99 per cent. purity.

Artificial graphite possesses the advantage over the natural variety that it may be produced in large, homogeneous masses, and does not require any binding materials. It may be machined with ease by ordinary workshop tools; thus it may be turned in the lathe to any desired shape or size, and may be filed, drilled, and threaded. Ordinary carbon, however prepared, is much more troublesome to work, and soon destroys the tool-edge. A comparison between Acheson graphite and amorphous carbon, with respect to physical properties, is appended:—

Property.	Acheson graphite.	Amorphous carbon.
Specific resistance, ohms per cubic centimetre .	0·000813	0·00325
Specific resistance, ohms per cubic inch . . .	0·000320	0·00124
Comparative sectional area for equal resistance	1	3·8
Specific gravity . . .	1·59	1·56
Tensile strength of rod, lengthwise, lb. per square inch. . . .	800-1000	1000-1500
Temperature of oxidation in air	640° C.	500° C.

It will be noticed that the most striking change resulting from the conversion into graphite is the improvement in electrical conductivity, which is increased nearly fourfold. The specific gravity is slightly raised, whilst the tensile strength is reduced and the temperature

of oxidation made higher by 140° C. For most purposes for which graphite or carbon might be used alternatively, the differences in properties indicated, on the whole, are in favour of graphite, which, however, is more costly than ordinary carbon. The thermal conductivity of graphite, taking the mean of a number of widely-differing results, is about ten times as great as that of ordinary carbon. The uses of artificial graphite will now be considered under separate headings.

Graphite Electrodes for Electrolytic Work.—In the electrolysis of solutions such as common salt, in which nascent chlorine is liberated, anodes of artificial graphite are superior to others, not being attacked by chlorine. In other cases in which corrosive substances are liberated by the electrolysis, such as the recovery of copper and nickel from residues, the same superiority is shown, and consequently artificial graphite is extensively used in such cases. A further advantage in this connexion is the ease with which it may be machined into shape, and fitted with leads for conveying the current. Electrodes of this material do not easily disintegrate mechanically, but are not suited for cases in which oxygen is liberated at the anode.

Graphite Electrodes for Metallurgical Work.—In the reduction of metals from their ores by the electric furnace, the usual procedure is to mix the ore with carbon on the bed of the furnace, and to pass a current through the mixture. The current is led into the furnace by graphite or carbon electrodes, and the points of superiority in favour of the former are (1) better electrical conductivity, enabling a much thinner electrode to be used, and (2) less waste from oxidation in the hot zone. These factors are sufficient in many cases to lead to a preference for graphite, in spite of its higher cost. As the electrodes wear away they are fed forward, and by screwing a new one into the end of the one in use, when the latter is getting short, continuity of the current can be secured. This practice is followed for both graphite and carbon electrodes.

Graphite for Dry Cells.—The superior conductivity of graphite renders it more suitable for filling the space between the two plates of a dry cell than carbon. A further advantage is its greater purity, so that it is not liable to cause local action. Special grades of graphite powder are made for this purpose, and find a wide application in cells for flashlights, telephones, and numerous military purposes.

Graphite for Paints.—There is probably no type of paint so suitable for preserving iron from rusting as one possessing a graphite basis, and natural graphite has long been employed for this purpose. The artificial variety is now largely used in paints, and is claimed to possess preservative properties equal to those of plumbago, in addition to a greater covering power.

Graphite Lubricants.—The use of graphite as a lubricant, mixed with oil or grease, is an old-established engineering practice, and natural graphite, specially purified for this purpose, such as Dixon's graphite, has given such satisfaction that replacement by artificial graphite, even if the latter possessed greater merits, would be difficult. Nevertheless, artificial graphite has found a certain application as a lubricant in the forms of "oildag" and "aquadag," both of which were introduced by Dr. Acheson. The graphite used in these cases is first ground down to a powder which will pass through a sieve of 40,000 meshes to the square inch, and afterwards treated chemically so that it forms a colloidal suspension in oil or water. Graphite of this character is said to be "deflocculated," and when suspended in a liquid will pass readily through a filter-paper. When added to oil the lubricant "oildag" is formed, and its use on a bearing results in the production of a thin layer of graphite on the rubbing surfaces, which, when formed, enables efficient lubrication to be carried on with a greatly diminished feed of lubricant. "Oildag" has been successfully used for many purposes, and Professor Boys, F.R.S., has found it to be highly suitable for delicate mechanisms, such as clockwork. For heavy engineering work, however, it has not yet replaced natural graphite to any great extent in this country. "Aquadag" is colloidal graphite suspended in water, and is recommended as a substitute for oil or soapy water in wire-drawing, drilling metals, and metal turning, being said to be more efficient than either for this purpose.

Miscellaneous Uses of Artificial Graphite.—Tubes for small electric resistance furnaces, muffles and crucibles for laboratory use, and pyrometer sheaths for withstanding extreme temperatures, may readily be constructed from Acheson graphite, owing to the ease with which it may be worked. Such appliances are in daily use, and have added greatly to the possibilities of conducting work at temperatures which would be destructive to ordinary metals or refractories.

[Specimens of artificial graphite in various forms were exhibited by E. G. Acheson, Ltd.]

Vitrified Silica.

When rock-crystal or sand is heated to fusion, and allowed to cool, it remains in a vitreous condition, and then possesses properties resembling those of glass. Vitrified silica thus prepared softens perceptibly at 1500° C., but is not completely melted until nearly 1800° C., and whilst in the plastic state it may be drawn out and blown in the same manner as glass. Boys was the first to employ vitrified silica for a practical purpose, and made very fine filaments of the material by shooting pieces from a softened quartz crystal with a crossbow, producing threads more suitable for delicate galvanometer suspensions than had hitherto been in use. Shenstone in 1901 carried the matter further by making tubes from a bundle of rods by fusion with the oxy-hydrogen blowpipe. A year or two later Heraeus in Germany and the Silica Syndicate in London made great advances in the blowpipe treatment of pure quartz, and introduced laboratory apparatus of transparent silica, such as flasks, crucibles, and test-tubes. The cost of such articles was somewhat prohibitive, owing to the high price of pure quartz and the expenses of manufacture; but the remarkable property of vitreous silica, whereby it may be quenched in water from a white heat without cracking, led many workers to attempt to produce it more cheaply by using a pure form of sand. Practical success was first achieved in this country by the Thermal Syndicate at their Wallsend works, an electric furnace being employed to melt up sand containing 99 per cent. of silica. In making tubes, for example, a current of sufficient power is passed through a graphite core surrounded by the sand, which is fused to a depth determined by the time the current passes. Care must be exercised not to exceed a temperature of 2000° C., as otherwise there would be a danger of the carbon and silica reacting to form carborundum. The core is then withdrawn, and the plastic mass pulled out into tubes of the required dimensions. By arranging the shape of the core, pieces with closed ends can be made, and afterwards blown in moulds to any desired shape by means of compressed air. A weight of 200 pounds of fused silica can now be produced and manipulated, thus rendering it possible to manufacture articles for commercial processes. A similar method is now followed in making transparent silica from pure quartz.

Silica articles made from sand are not nearly so transparent as those from quartz. This is due to the presence of air bubbles derived from the sand, which are unable to escape through the fused mass. For this reason the specific gravity is lower than the air-free product obtained when pure quartz is used, the figures being 2·07 and 2·2 respectively. The coefficient of expansion, however, is practically the same in both cases (52×10^{-8}), or only $\frac{1}{17}$th that of glass; so that the resistance to fracture due to sudden changes of temperature is the same in both varieties. As in most of the uses to which vitreous silica is applied transparency is not essential, the cheap material made from sand meets nearly every requirement, and has proved most valuable for a variety of purposes, both chemical and electrical.

Vitrified silica, from the chemical standpoint, possesses the valuable property of being proof against acids, with the exception of hydrofluoric, and phosphoric above 400° C. This fact, combined with its capacity for withstanding changes of temperature, has enabled it to replace with advantage porcelain and earthenware in industrial chemical processes. In the best modern plant for the manufacture of nitric acid from saltpetre, the product is condensed in silica pipes, which may be water-cooled without danger of cracking; and in concentrating sulphuric acid silica basins are now used. The production of the enormous quantities of these acids needed for the manufacture of explosives has been much facilitated by the use of silica apparatus; and in addition the output of vessels and pipes of various kinds has proved of advantage to chemical industries generally, in all cases where acid and heat-resisting properties are of importance. A further advantage of silica ware is that it is non-porous. It is attacked, however, by alkalies, either fused or in solution.

In the laboratory, silica apparatus, either of the transparent or semi-transparent type, is much used instead of glass for various kinds of vessels and combustion tubing, in cases where heat-resistance is of importance; and as a substitute for porcelain in crucibles, basins, combustion boats, etc., as, unlike porcelain, it is not liable to crack on sudden heating. Practically all glass apparatus may be reproduced in silica. One of the most useful applications of vitrified silica is in connexion with small electric furnaces of the resistance type, in which a tube or muffle of silica is wound with nickel-chrome wire or strip, and insulated thermally by asbestos or other material. In these furnaces a temperature of 1000° C. may be attained with a small expenditure of current,

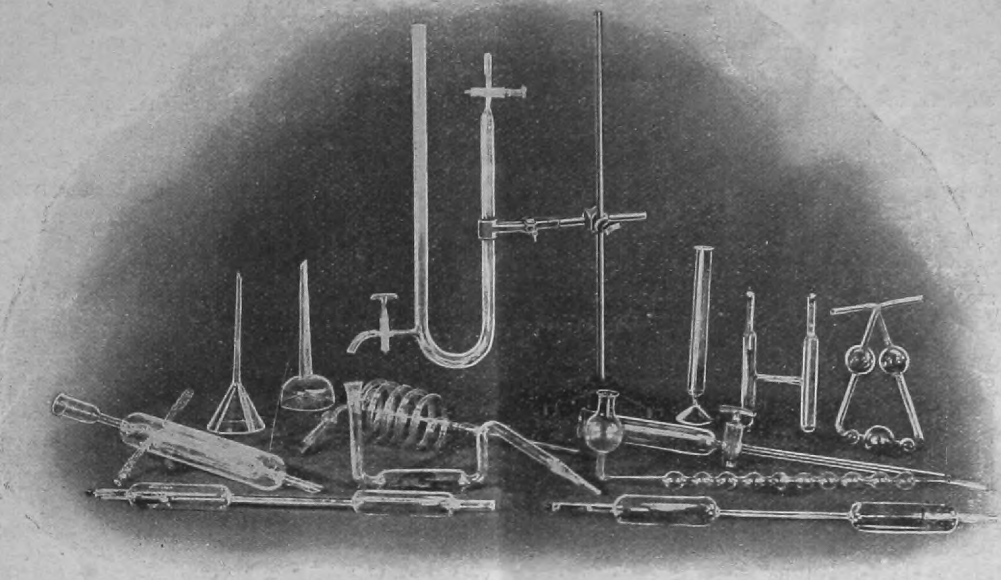

FIG. 9.—GROUP OF ARTICLES MADE OF TRANSPARENT SILICA.

and they are now extensively used for chemical combustions, and for the heat treatment of steel articles such as dies, taps, and gauges, where a precise temperature regulation and clean atmosphere are required. The advantage of silica in this relation is that there is no danger of cracking when the current is switched on. The present lecturer was one of the first to use silica for this purpose, and soon afterwards Bastian applied the idea to electric radiators for warming rooms, this form of heater having now almost entirely replaced the large carbon-filament lamps formerly used.

Silica sheaths are largely used for protecting the wires of pyrometers, and not being penetrated by furnace gases, are well suited to this purpose. Silica, however, if heated for a long period above 1200° C., undergoes devitrification, and is liable to weaken and crack, so that its use in pyrometers is restricted to temperatures below 1200° C., except for occasional readings.

Another useful application of silica has been found in connexion with lighting, as a substitute for glass in chimneys and bulbs. The semi-transparent variety is used to surround gas-mantles, the chimneys being of less diameter than would be permissible with glass. The result is that the mantle becomes hotter and more luminous, and the light is softened by passing through the material. For electric lamps of the "half-watt" variety, which contain nitrogen, clear silica has been used, resulting in the production of a much smaller lamp than is possible when glass forms the enclosure. For scientific work, vacuum tubes of clear silica have been constructed, the electrodes being made of molybdenum wire, sealed in position by a special joint of metallic lead.

There are many other instances in which vitrified silica may be used to advantage, and there is little doubt that its use will extend as improved methods of production bring about an accompanying reduction in cost. The gratifying fact that this country has always been to the fore in the production of silica ware is due to the enterprise of the Silica Syndicate, who have specialised in the clear variety, and the Thermal Syndicate, who have produced the cheaper form under the name of "Vitreosil." Examples of silica articles are shown in Figs. 9 and 10.

[Specimens of clear silica ware and "vitreosil" articles were exhibited at the lecture by the Silica Syndicate, the Thermal Syndicate, and Messrs. Johnson & Matthey.]

HIGH TEMPERATURE PROCESSES IN BRITAIN.

It will be recognised by all who have studied the matter closely that the future industrial success of any country will largely depend upon the extent to which it develops high temperature processes. Most of our advisers in connexion with after-war policy agree in stating

that increased production will be essential if we are to recover our financial position; but this is a conclusion which requires qualification. Merely to increase production in the case of existing industries would probably lead to over-production, and almost certainly to stagnation. Increased production there certainly must be, but additionally, if we are to hold our place, new industries must be developed, amongst which work at high temperatures will play an important part. The remarkable growth of electric steel furnaces in this country during the last four years is an indication of the trend of events which we cannot afford to ignore; and the ever-increasing importance of high temperature products serves further to point out the direction in which effort will be necessary. One of the first essentials will be a cheap and abundant supply of electricity, and it is to be hoped that not only the sixteen super-power stations proposed by the Coal Conservation Committee, but many others, will be erected, entirely apart from considerations of economy in coal. The question as to how far we shall be able to compete with other countries possessing abundant water-power is one that cannot be generally answered, as each process must be considered separately in relation not only to heating costs, but also labour charges, proximity of raw materials, freights, etc. In the paper recently read before the Society by Mr. Newlands on "Water Power in Great Britain," it was shown that the unused water-power in Britain amounts to at least 400,000 horse-power; but the drawback is that the sources are scattered and in most cases remote from centres of supply of necessary materials. Whilst in some localities it might be possible to establish special industries, there is little prospect of competing in water-power installations with more favoured countries such as Norway and Switzerland; and it would appear that we must rely upon our supplies of fuel for generating electricity on the large scale. A typical example is furnished in the case of calcium carbide, now an indispensable material for the production of acetylene, in addition to its other uses. To manufacture one ton of this material involves a consumption of 4,000 kilowatt-hours, the cost of which at the hydro-electric installations in Norway is about £1 5*s.*; whereas the fuel costs in this country, even in a good power-station, are about ·35*d.* per unit, or £5 16*s.* per ton of carbide. This difference, after allowing for freights and other costs, is sufficient to throw coal-generated electricity out of competition for producing carbide. Schemes are put forward from time to time for treating coal in such an advantageous manner as to obtain heat practically for nothing, by gasefying in special ways and recovering by-products; but so far none of these have proved successful in achieving this end. It may be possible to accomplish this, but judging from past experience we should be unwise to rely on this solution of the problem. Mr. Chas. Bingham, who is well known as an authority on

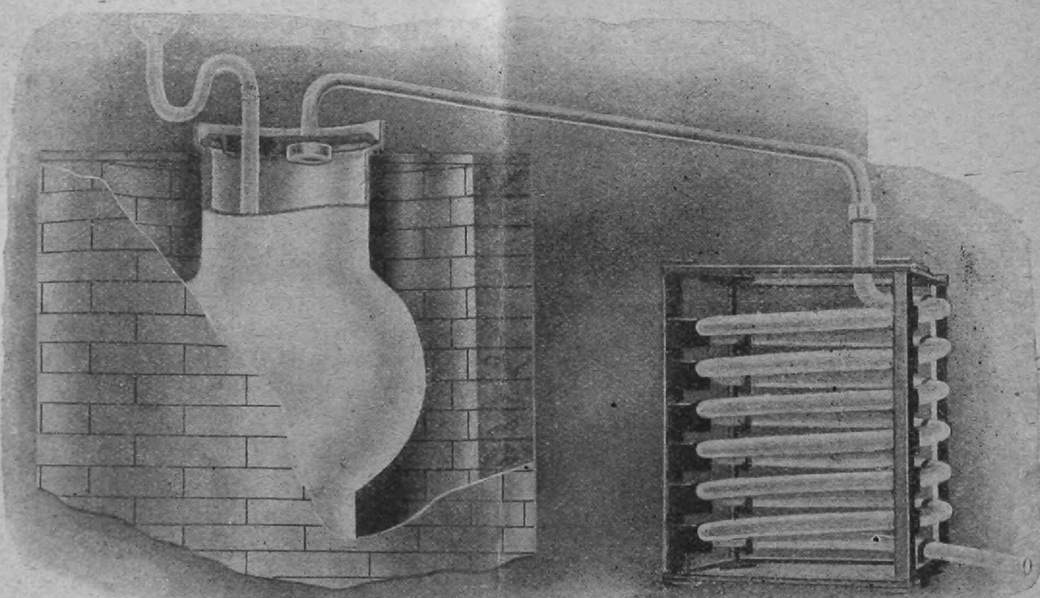

FIG. 10.—RETORT AND CONDENSING COILS MADE OF SILICA.

calcium carbide, has pointed out that the surplus gas from blast furnaces and coke ovens, over and above that which can be utilised for various purposes on the spot, amounts in the aggregate to a very large quantity. If, therefore, the carbide furnaces could be established in proximity to blast furnaces, power should be obtainable at a rate sufficiently cheap to enable carbide to be produced economically in this country. The amount of heat wasted industrially is appalling; and any suggestion of a practical nature to utilise this waste should be welcomed.

In considering other high temperature products such as carborundum, the heat costs do not bear such a high ratio to the cost of the finished article as in the case of carbide, as the raw material is treated in various ways before marketing. In a case of this kind the disparity in the cost of production becomes proportionately less, and taking into account items such as freight and access to raw materials, competition with hydro-electric power becomes a possibility. Moreover, it is now possible to purchase electric power as cheaply at Newcastle as at Niagara, the great centre for electric furnace products; and there appears, therefore, to be no economic reason why carborundum and graphite, for example, should not be manufactured in England. The development of cheap power schemes should lead to the establishment of many new industries in this country, provided the necessary enterprise and capital be forthcoming.

High Temperature Research.

One effect of the war has been to create a general appreciation of the value of research in connexion with industry, and efforts have been made in many directions to make good our previous negligence in this respect. Although it is not always possible to distinguish between "pure" and "applied" science, there is no difficulty in recognising the difference between a research which has only in view the discovery of new phenomena, and one intended to cheapen or to develop industrial production. Both types of research are essential to progress, for the laboratory discovery of to-day may become the commercial process of to-morrow. Our fault in the past has probably been that our leading exponents of science have devoted themselves almost exclusively to "pure" science, with the result that many industries have suffered owing to the absence of the continuous research necessary for success under modern conditions. So far as high temperature processes are concerned, our record is not one of which we may be proud, as, with the exception of silica ware and aluminium, we are dependent on other countries for materials which have now become indispensable. The chief reason for this has no doubt been the absence of cheap electricity; but now that this is to be remedied no time should be lost in commencing high temperature research on various lines. Amongst problems awaiting solution may be mentioned the smelting of tungsten and other metals of very high melting-points, and the formation of alloys of these metals, the production of suitable refractories for use in electric furnaces generally; and the manufacture of the diamond on the large scale for abrasive purposes. Apart from these obvious lines of research, the production of new compounds as the result of high temperature reactions offers a boundless field for investigation, and should lead to important industrial developments. It is only necessary to consider the results which have accrued from the heating of coal and lime, coal and sand, and carbon alone, in the electric furnace, to realise the possibilities in this direction, and the imperative need for research on the lines indicated.

A commencement has been made by the installation of an electric furnace at Sheffield University, of sufficient capacity to enable experiments on steel to be carried out on an industrial scale. A good electric furnace, capable of taking charges which would enable commercial possibilities to be deduced, should be installed at all the leading centres of scientific instruction; and wherever possible the work should be carried out in co-operation with the industry involved, as in the example set by Sheffield. One or more such furnaces, devoted to general research, should be established in London; and, speaking from personal knowledge, there would immediately be many firms desirous of submitting problems, the solution of which would be an aid to the industries in which they are engaged. The erection of suitable furnaces and the charges for current and upkeep would be considerable, but the results would repay the costs many times over. This is a matter which might well engage the attention of the numerous scientific societies in London, with a view to conjoint action, unless some public benefactor may be found who will provide the necessary funds. In the provinces other centres may be relied upon to continue the movement initiated by Sheffield, and it is to be hoped that

before long high temperature research will be flourishing in this country as it has been for some years in America. The factories at Niagara, with their enormous output of various materials, are the outcome of this research, and given adequate facilities in this country for investigation, there is no doubt that we should reap our full share of the future developments which are certain to arise in this field of work. On the other hand, failure to commence work in this direction, or undue delay, will probably lead to serious commercial drawbacks, and place us at a disadvantage as compared with our trade competitors. For the future of industry lies largely with high temperatures.

INDUSTRIAL DEVELOPMENT IN INDIA DURING THE WAR.*

By D. T. Chadwick, I.C.S.,
Indian Trade Commissioner.

It is a well-known truism to say that India is primarily an agricultural country. Except for the large cotton, jute and coal interests, industries in India in the early years of this century were either confined to a few factories or were still continuing on a village scale. Thus in the year before the war, in the sixteen principal articles of export of a total value of £150 millions, only two classes of manufactured goods figure, viz., cotton and jute. On the other side, except for sugar, the principal imports consisted solely of metals and manufactured goods, among which cotton and iron or steel goods took leading places. It was thus not surprising that on the outbreak of war the first economic anxiety centred round the difficulties of selling agricultural produce, for though most of the crops were sown, it seemed that, by the time they came to harvest, markets would be either non-existent or very restricted. For some articles these forecasts proved true. Difficulties have continued, and in some cases become more intensified, yet on the whole this stage soon passed as it became clear that many of India's raw products were essential for the prosecution of the war—as, for instance, jute, wheat, wolfram, lac, mica, castor seed, hides, etc. The first phase of the second stage supervened, viz., the need for a greater and more varied industrial output from India. The causes which called for this effort are still acting, some with increased force. They are, briefly, the need of supplying from India, as far as possible, many of the requirements of the armies operating in the East, and the necessity of supplying local wants for which the ordinary sources of supply are cut off, either through lack of shipping, or through being otherwise engaged. The industrial effort thus called for has taken three forms: (1) the establishment of new factories or the expansion of existing ones, (2) the organisation of such industrial resources as India possessed, and (3) the closer examination of local resources in the search for substitutes, etc. It is far too early to attempt a full account of India's economic efforts during this time of war. That story I hope will be told some day. Nor is an exhibition of scientific products the time to dwell on the business organisation of this effort —rather, I will attempt to indicate a few of the main lines on which inquiries for the greater utilisation locally of India's own resources have proceeded. Unfortunately there has not been time to obtain complete exhibits from India. Many of the inquiries I shall refer to will necessarily seem to be on a lower plane than the scientific inquiries undertaken during this war in this country; but the results are likely to be as relatively important to India as those obtained here, according to all our hopes, will prove important hereafter to this country.

Even before the call for widespread organised industrial effort was made the larger factories in India had contributed most helpfully to Army supplies. The jute-mills of Calcutta supplied many of the millions of sandbags and yards of sacking required, whilst almost from the outset of war Indian cotton-mills met the needs of khaki cloth, etc., for the ever-increasing armies in the East, which for khaki cloth alone now run to over twenty million yards a year. In the first half of 1915 the railway workshops, as well as those of the principal engineering firms in Calcutta and Rangoon, undertook to supply shell-cases to supplement the output of this country. And this continued until the Ministry of Munitions in England had so developed its own organisation as to be independent of any supplies from India. It was fortunate at that time of anxiety that India could to some extent help. But it was only just rendered possible. The steel used, which was according to United Kingdom specification, was all supplied by the Tata Iron and Steel Company, and was of such quality that not a single shell was rejected at gun proof for defective steel. Without these steelworks India could not have rendered such aid; yet these steelworks were

* Delivered at the British Scientific Products Exhibition, September 3rd, 1918.

only erected in time. The first steel ingot at these mills was only rolled in February, 1912, and the first rails a month later, *i.e.* a little over two years before the outbreak of war. Some time is always needed for a steel factory to get settled down to work, especially when it is the first of its kind in a country, and all labour has either to be imported or trained, and still more when, in addition, the whole site of the works, mines, etc., was tropical, and practically uninhabited jungle only four years previously. The utility of these steelworks did not cease with the provision of steel for shell-cases. They have been the chief source of supply of rails for Mesopotamia and Africa. Extensions of the works have been undertaken, and a rolling-mill is being erected which will give steel plates of any length and up to 90 in. in width. A supply of such plates obviously opens a large vista of future possible developments. In addition, the Bengal Iron Company has helped largely, and now another iron and steel company has been formed under strong auspices to develop other large iron deposits. Without these steelworks India's contribution of finished material to the armies in many parts must have been very much less than it has been, and the burden would then have been thrown on this country. These instances of sandbags, khaki cloth, and steel, serve to illustrate in a small way how the wise development of industries in India on modern lines not only benefits that country by establishing a better local balance of employment, but is a source of strength to the Empire in general in a time of need.

The cases so far quoted relate to large firms in existence when war started. But as time went on, more widely co-ordinated efforts were needed to supply as far as possible essential articles both for the armies and the civil population. For this purpose the Indian Munitions Board, under the able control of Sir Thomas Holland, was started in April, 1917. It was clearly a great undertaking to attempt to organise industry in war time in a country in which over 70 per cent. of the population were normally engaged in agriculture, and in which there are at least twenty-three different languages, each of which is spoken by more than a million people. It was impossible to make India self-supporting in manufactured goods in the time, and no such visionary ideals were entertained. But very much more has been achieved alike in quantity, quality and variety than three years ago seemed possible. This result has been largely due to the whole-hearted and ready co-operation and help which the business community in India of all classes and grades has given to the Munitions Board. As one instance of the speeding-up which has resulted from such co-operation, it may be said that the Karachi Committee took about six weeks to convert a vacant tract of foreshore into a village with workshops, workmen's houses, etc., complete for the re-erection of sectional barges. And whilst at first nineteen days were required for the re-erection and launching of one barge, some few months later they were rarely turned out at a rate of less than four a week, and at times a speed of six a week was obtained.

The realm of forestry is one which has come in for searching examination during this period. In spite of a forest area of over 250,000 square miles, imports of timber into India exceeded exports by some twenty to thirty thousand tons a year before the war, excluding firewood, railway sleepers and ornamental woods. These imports consisted largely of teak, hardwoods and pine. In one instance even wood was imported from Siam when exactly the same was available locally at lower price. This extensive employment of imported timber has been ascribed to a general want of sufficiently precise information regarding the timber resources of India. This defect could not be remedied in a day, but the present vital need of developing local resources has drawn great attention to it. Timbers have been found locally which even meet the high specification required for aircraft, though for this use the specific gravity requirements are defined within such narrow limits as to restrict the range of choice. These have now to undergo searching practical test. Two timbers are being tested practically, as they are expected to prove suited for rifle manufacture, whilst in the lower categories much of the imported pine and fir could be replaced in ordinary scantling sizes by the pine and fir of the Himalayas. A substitute even for Oregon pine is available if improved engineering facilities are afforded. Meanwhile stocks of timber cut to sizes have been accumulated in various ports, and the Indian Munitions Board, since its inception, have sent overseas for Army purposes more than twice as much Indian timber as was ever exported in time of peace. The work of the Forest branch has not, however, terminated here. Researches and trials have been continued as to the best ways of preserving bamboos—a most important issue

in any tropical country. Increased attention has also been paid to the resin and turpentine industries in North India, and the resin now produced in the Punjab has recently been pronounced by a commercial firm in London as superior in some respects to that from France. Whereas before the war India imported annually some 3,000 tons of resin, the local output has now been more than doubled and is about 2,500 tons. Similarly, in regard to turpentine, the local supply has been more than doubled, and now exceeds 120,000 gallons. The increases have been attained largely by improved methods, and after the war, when again it becomes possible to obtain machinery, much larger quantities should become available. Inquiries are being pushed on in co-operation with business houses in other directions in which forest resources are essential to industries, as, for instance, in substances suitable commercially for some grades of paper pulp, in wood distillation, and in the testing and exploitation of tanning materials. In regard to sandal-wood oil, the Mysore Government seems to have captured one trade which hitherto had largely centred in Germany. Before the war, sandalwood to the value of over £100,000 was exported annually. The factories established in Mysore since the war are now capable of turning out nearly 20,000 lb. weight of oil a month of the highest quality, well suited for medicinal purposes. Within eighteen months of its inception, the monthly turnover had reached £20,000. Considering that the export of oil instead of wood means a saving of some 90 per cent. in freight, and that oil of high quality is now made, it is reasonable to hope that this industry will remain in India.

For tanning materials, efforts have proceeded on three main lines :—

(1) Encouraging the cultivation by special concessions of *cassia auriculata*, the favourite tanning reagent in Madras.

(2) The preparation of tannin extracts, especially of myrabolams, for hitherto the raw fruit has been exported, and not the extract.

(3) The systematic inquiry and testing at the factory at Maihar of numerous other tannin reagents and combinations thereof. These form a very important line of inquiry, as India has a very large output of hides. The undue weighting of hides and damage by faulty flaying have often proved a heavy handicap to Indian kips. It cannot be pretended that these difficulties have been entirely or effectively surmounted, but all exports tend to show that a vast improvement has occurred owing to control and the need of working to the high Army specification. Concurrently there has been a large increase in the output of leather goods of all kinds, many of which had not hitherto been made in any quantity in India—from the many articles for military equipment to leather belting and pickers for cotton-mills. The Cawnpore leather factories are among the best known in India, but others are being erected with modern equipment, especially round Calcutta.

In an entirely different category come a large range of medical stores and surgical requirements. In spite of the vastly increased demand for these articles, many which were previously imported are now entirely manufactured locally ; among these may be cited loose woven bandages, absorbent cotton wool and yarn, etc., and gauze, double cyanide, compressed and uncompressed, carbolised and boric wool, and many forms of bandages, etc. The glassworks in the north have been able to make satisfactory Petri dishes, glass tubings and flasks, whilst attached to the Medical Store Depôt at Bombay is a private concern employing some hundreds of workmen in the manufacture of artificial limbs of the most approved modern type. Very similar progress has been made with drugs. Whereas before the war, absolute alcohol, refined petroleum, lysol, etc., and many of the preparations from belladonna, and nux vomica, were entirely imported, they are now being made satisfactorily in India. Thymol, ether for pharmaceutical purposes, quinine hydrochloridum, acidum, strong ammonia, etc., are all now obtainable locally. Many other medical essentials have been made in limited quantities, as, for instance, amylum from rice, tannic and gallic acids, salicylic acid and its sodium salt, and methyl alcohol, etc.

(*To be continued.*)

INDUSTRIES AFTER THE WAR.

II.—ENGINEERING.

The recently-issued report of the Departmental Committee appointed in July, 1916, to consider the position of the engineering trades after the war is very comprehensive, and with statistical tables extends to upwards of fifty pages. The earlier and not least interesting sections deal mainly with the pre-war conditions of the trade. The only particulars available as to the magnitude of those

branches which formed the subject of the Committee's investigations—the electrical industries and marine engineering, for example, were referred to separate committees—are those compiled under the First Census of Production and relate to the year 1907. The gross value of the output, including duplications and cost of all materials used, was given as about £168,500,000, and the net value, excluding duplications and cost of materials, as about £84,000,000. The real value lies between these two figures, and is put at about £144,000,000 including cost of materials but free from duplication. The number of male persons employed in engineering generally at the outbreak of war was 812,000, of female persons 52,000. In October, 1916, the figures had risen to 918,000 and 233,000, 85 per cent. of male and 90 per cent. of female labour being employed on Government work. The totals include those working in national factories, approximately 114,800 men and 99,000 women, according to information available when the report was written, eighteen months ago. "There is no doubt," the Committee observe, that "on light work involving repetition, female labour is quite as good as male labour. Although some employers have, for various reasons, expressed their unwillingness to continue to employ female labour after the war—reasons which do not seem to us always good ones—there is no doubt that most employers will be anxious to continue to employ female labour on the lighter repetition work." Indeed, it seems to the Committee that the continuance of a certain amount of female labour is "both necessary and desirable."

As regards the position of the industry immediately after the war, the employment of practically the whole of the engineering firms in the kingdom upon munition work has necessitated the installation of large quantities of machines, some bought in the United States of America, some made at home; plant already in position has been disturbed and rearranged, and there has been a general dislocation of the scheme of manufacture as hitherto carried out in many works. Generally speaking, it is not anticipated that the additions will much strengthen the position for post-war purposes. Much of the plant has been put down for shell work, and the grouping and balance of machines for this manufacture are unsuitable for other purposes, and many of these will be of little use for general engineering work when the war is over. Many of the machines bought early in the war were of too light a type and have not stood the heavy work put upon them. It may be assumed that even the heavier machines have suffered from continuous work, and will be in a worn condition, urgently needing repair; and it will be some considerable time before it will be possible for the engineering works throughout the country to resume the regular current of their normal work. With regard to the buildings that have been erected, they are generally light in character, but will be useful where medium and light trades are carried on.

The knowledge that work is being done by controlled firms without competition has produced a feeling amongst workmen—and, indeed, amongst the staffs—that, as the Government pays, the rates of wages can be indefinitely increased, and that no particular attention need be paid to cost. In the necessary pressure to produce work urgently required, many concessions have been made in the matter of wages, with the consent of the authorities, which would be impossible in normal working. The controlled firms, when the control is lifted, will have the greatest possible difficulty in reorganising their pay-sheets upon anything like normal working lines. There is the further possibility that some portion at least of their output will, after the war, be earmarked for the necessities of the reconstruction of Belgium and the invaded portions of France. All these things seem to the Committee to entitle the controlled firms to special consideration.

As a matter very relevant to the consideration of international competition after the war, the Committee think it necessary to refer to the great growth of engineering works in Canada since 1914. With a population of eight millions, Canada is said to be equipped with engineering works capable of dealing with the wants of twenty-four millions of people. "If this is true," say the Committee, "the competition of Canada may hereafter have to be included in any reckoning of international trade." Moreover, intelligence, enterprise, and cheap labour combined, may easily make Japan a formidable competitor, in spite of her relative lack of coal and ironstone.

Among the witnesses examined, the larger and more prominent firms naturally predominated. This might give a somewhat false impression of the size of the units carrying on the engineering trade in this country. Actually, the smallness of the individual firms and of the capital they employ was most noticeable. "There are, of course, exceptions, but on the whole it is clear that the engineering trade of this country is in smaller hands than in the United States of America and in Germany, though the difference is probably not so great as in the coal and steel trades." It appears to the Committee that before the war there was a considerable proportion of plant in existence which would not represent anything like the value at which it appeared in the owners' books, and was not turning out enough work to be economically employed. Such plant is still in existence.

Throughout the evidence the Committee were confronted with large purchases before the war from the United States of machine tools unobtainable here, or if obtainable at long delivery only. Since the war considerable strides have been made in the manufacture of these articles, and witnesses who had bought special tools abroad before the war admitted that they were now able to obtain some types of them at home.

While advocating research at the universities the Committee declare that no trade will be progressive that relies entirely upon outside assistance for

experimental work and the investigation of new problems. "If the engineering business cannot be organised on such a scale that the larger firms could have adequate scientific departments, then we should recommend that some collective effort be made to establish such a department by a combination of firms in the same branch of trade, and we know that this has been successfully accomplished in Germany."

As to imported materials, the Committee say that the real motive actuating the purchase of many of the articles alluded to was varyingly based on quality, price and delivery, as to all three of which the British purchasers were insistent on the superior advantages offered by foreign countries. "There seems to be no reason why, in the large majority of these cases, this country should not in future shake itself free from all dependence on outside sources, provided that works organised to produce these articles are on large enough scale."

The summary of recommendations with which the report ends includes the following :—

"To give time for the reorganisation of the engineering works of this country on a business footing after the war the importation of enemy engineering products into the United Kingdom be prohibited, except under license, for a minimum period of one year and for such longer period as may be deemed expedient.

"To encourage trade between present Allies they be invited, without interference with their existing fiscal systems, to consider the imposition of an additional duty or surtax over and above their normal duties, to be levied solely against the products of the present enemy countries, such surtax to be subject to progressive diminution.

"That this country impose a duty equal to such surtax on the products of present enemy countries and to be subject to like progressive diminution.

"That raw materials be admitted to this country duty free.

"That a Government Department be charged with the duty of exercising vigilance over the adequate provision in this country of manufactures, as distinct from our staple trades, which are at any time essential to the national safety: such as tungsten and magnetos.

"That the development of the supply of raw materials within the Empire for such essential industries be supervised, encouraged and assisted by the Government.

"That all necessary steps to protect such essential industries be taken by the Government whether by prohibition, tariff protection or subsidy.

"That 'dumping' of goods as defined by American Law be prohibited by legislation.

"That the Government control of industries be lifted as soon as possible after the war, having regard to the interests of the manufacturers. That allowances under the Munitions Act be made with particular regard to the necessity of leaving firms unimpaired for the conduct of post-war competition in the export markets.

"That it should be the recognised duty of Government Departments, municipalities and corporations, to purchase, as far as possible, goods only of British origin, due precaution being taken to prevent price rings.

"That in the interests of the country the engineering manufacturers be encouraged to work together in larger units, either by amalgamation or by joint working, by pooling of resources, by specialising production, and by organisation of export sales, and for the purchase of raw materials.

"That standardisation of products should be more widely practised. The work of the Engineering Standards Committee deserves to be assisted.

"That the proposed British Trade Corporation be supported as promising to provide much needed help for the engineering trade.

"That India and the Dominions be invited to concede an effective preference to the goods of the British Empire.

"That all goods of foreign origin should have clearly and indelibly marked upon each article the words 'Not British.'

"That 'Summer Time' be permanently enacted.

"That every effort should be made to develop and encourage the medium and light engineering trades, whether already existing in this country or not; thereby making use of the workshops, motive power and equipment installed for war purposes and finding suitable employment for the large body of semi-skilled and female labour recently created."

MAHOGANY PRODUCTION IN GUATEMALA.

Exact statistics as to the mahogany resources of Guatemala are not available, but it is known that the timber exists in practically unlimited quantities in the northern part of the Republic, known as the Peten country, while another defined zone or belt is found in the western or Pacific coast region. The outbreak of the European war caused a sharp curtailment in the export movement of mahogany, shipments for a time being practically suspended. The country, however, has in a measure recovered from the depression due to the war, and mahogany is again beginnning to move, shipments being confined principally to the United States.

The Usumacinta River, forming part of the Guatemala-Mexico border, is largely employed in rafting mahogany logs to the Mexican port of Frontera, where shipments are made to the United States. The timber is also rafted from the Peten region *viâ* the Belize River to Belize, British Honduras, where exports are made principally to England. Timber in smaller quantities is found along the Gulf coast in the vicinity of Sarstoon and Livingston, the logs from this section going chiefly to the United States.

According to a report by the United States Consul at Guatemala City, a well-defined timber belt parallels the Pacific coast of Guatemala at distances varying from five to twenty-five miles

from the ocean and extending from Coatepeque to the Salvador boundary on the south. San José and Champerico are the principal exporting points for this territory. Much of the timber accessible to transportation facilities has already been cut, and it is estimated that not more than 15,000,000 to 20,000,000 feet remain that would be commercially profitable to export.

Fully 90 per cent. of the mahogany in this region is found within twenty-five miles of the coast. The timber is scattered and is said not to average more than one tree to five acres. The timber is hewn and hauled in ox-carts to shipping points along the Occidente Railway and the division of the International Railways of Central America extending from Guatemala City to San José. The construction of additional railways and the completion of the proposed intracoastal canal, known as the Chiquimulilla Canal, would give impetus and encouragement to the mahogany industry of the west coast. There are many rivers, nearly all of which are navigable for rafting purposes, including the Michitoya, Guacalate, La Gomera, El Naranjo, Coyolate, and several others, which are not utilised at this time for the reason that San José and Champerico are the only licensed ports for the Pacific Coast.

In this region are a number of mills, which saw chiefly mahogany and cedar. Some of the lumber is exported *viâ* San José and Champerico, while shipments are also made to Guatemala City, where several furniture factories are now in operation.

First-rate mahogany f.o.b. San José is worth £16 per thousand feet, of which total cost £2 10*s.* represents the loading charge and the export duty of 8*s.* 4*d.* per ton, and £1 to £3 represents the railway transportation.

The ocean rate on mahogany lumber, Puerto Barrios to New York or Boston, is £3 per thousand feet, and on logs £4. The rate San José to San Francisco or Seattle is about the same.

Producers of mahogany operate under a Government concession, granting them the right to cut and remove timber from a prescribed area.

Mahogany is not separately shown in the customs statistics of Guatemala, but it forms the bulk of all export shipments both of timber and lumber. The report of the Minister of Finance and Public Credit for 1915 shows that lumber to the amount of 3,524,622 quintals (metric quintal = 220·46 lb.), valued at £36,700, was exported *viâ* San José and the frontier custom-house of Peten. For 1916 the total exportation amounted to 2,339,276 quintals, valued at £24,300, all going to the United States.

OBITUARY.

Horace Porter, M.A., F.R.I.B.A.—Mr. Horace Porter, who died on July 29th, at the age of fifty-seven, at his house in Russell Square, became a member of the Society in 1895. He was educated at Uppingham and Trinity College, Cambridge. After taking his degree he studied architecture under his father, Mr. F. W. Porter, and was taken into partnership by him, starting in practice in 1890. About fifty years ago Mr. Porter, senior, was appointed architect and surveyor to the Sun Fire Office, and also surveyor to the Clothworkers' Company. In both offices his son succeeded him. They were responsible for various important buildings in London, including the offices of several banks and insurance companies, as well as for some private country houses.

Mr. Horace Porter was Master of the Saddlers' Company last year. He took a very active part in local administrative matters, having been an original member of the Holborn Borough Council, and Mayor in 1910-11. He was also an energetic Freemason, having been secretary of a well-known London lodge for ten years, and Grand Treasurer of the Degree of Mark Masons. He married, in 1901, Mary, the youngest daughter of the late G. P. Bidder, Q.C., the eminent Parliamentary Counsel.

Frank Garrett, M.Inst.C.E.—The late Mr. Frank Garrett, whose death occurred at Aldringham on August 2nd, was born at Leiston on May 6th, 1845, and educated at Rugby and Stuttgart. He was elected a member of the Society in 1878, an Associate Member of the Institution of Civil Engineers in 1869, a Member of the same institution in 1880, and a Member of the Institution of Mechanical Engineers in 1882. On the death of his father, the sixth Richard Garrett, he became a partner, with his two brothers, Richard Garrett and Henry Newson Garrett, of the well-known business, Richard Garrett & Sons, manufacturers of agricultural machinery and implements. Mr. Henry Newson Garrett retired in 1878, and Mr. Richard Garrett died in 1884, leaving Mr. Frank Garrett the sole proprietor of the business, which, in 1897, for family reasons, he converted into a private limited liability company. Mr. Frank Garrett was a man of very progressive spirit, and as far back as 1867 was producing traction engines with Boydell's patent wheel attachment for taking heavy weights over soft ground. In 1870 he started making malleable castings under Tenwick's patent, and was one of the first, in 1880, to adopt artificial means of drying wood under McNeill's patent. He may certainly be regarded as one of the pioneers of flanging steel boiler-plates by means of hydraulic machinery, having put down a plant for this purpose in the early seventies. In 1880 he took out a patent for his steel corrugated firebox for locomotive type boilers, which not only did away with all crown stays, but was a most efficient firebox, giving an increased heating surface of about a third over the ordinary flat-top box, and forming what may be styled a half-water tube in the midst of the hottest flames. This was to a very large extent copied by German and Austrian competitors. In 1881 Mr. Garrett introduced the

first compound portable steam-engine, which formed the progenitor of the high economy superheated steam semi-stationary engines, now one of the staple products of the firm.

Amalgamation of metals occupied a great deal of Mr. Garrett's attention at one time, and he made extensive and repeated experiments in the mixing of alloys, with a view to determining the best combinations to meet the requirements of various types of bearings.

Mr. Garrett was never idle. When not at work directing his business, he was, besides being a good all-round sportsman, always busy in public work or in helping others. He was a Justice of the Peace for the county of Suffolk, and one of the original members of the East Suffolk County Council, of which he was early made an alderman, taking a great interest in educational matters, and for a long period holding the office of Vice-Chairman of the Technical Education Committee of the Council. He was also for many years Chairman of the Governors of Framlingham College, which, to a large extent by the efforts of his father, was founded in memory of Prince Albert. Under Mr. Garrett's guidance the college rose to its present high state of efficiency. Mr. Garrett was a cousin of the late Dr. Elizabeth Garrett Anderson.

GENERAL NOTES.

EDUCATION IN THE ARMY.—The *Times* understands that Colonel Lord Gorell, M.C., has been appointed to take charge, under Major-General Sir Arthur Lynden-Bell, of a new Department of the Directorate of Staff Duties, which has been formed to direct and to co-ordinate education in the Army. An Inter-Departmental Committee, to which various Ministries have nominated representatives, will advise on general principles, and the Department will have within it a distinguished educationist as civil expert, assisted by a sub-committee of other educationists. It is hoped to develop a really comprehensive scheme, which shall minimise as much as possible the break in studies and the loss of skill caused by the calling up of the whole youth of the nation.

THE KING'S FUND FOR THE DISABLED.—The trustees of this fund, for whom the Minister of Pensions, Mr. Hodge, signs as chairman, make an urgent appeal for subscriptions "which will help to find a new place in civil life for officers and men of His Majesty's Forces disabled in the War, and for the widows and children of officers and men who have given their lives for us." It is pointed out that, apart from a State pension scale, there is a great human field which the King's Fund can cover. The amount aimed at is £3,000,000. His Majesty has not only given his name to this "monument of gratitude," but subscribed £78,000. Mr. Hodge says: "We are receiving 600 applications a week; 2,500 cases have been dealt with thus far. Where the officer or man has been trained by the Ministry of Pensions, or where there is a business given up for war service which he can restart, an adequate grant can be made." Men and women have been helped to establish themselves in the following and other businesses: boot repairers, greengrocers, drapers, clothiers, tailors, cycle repairers, tobacconists, newsagents, carpenters, plumbers, allotment holders, builders, poultry farmers, pig breeders, taxi drivers (to buy cab on hire purchase), hawkers, costermongers, window cleaners, etc. Grants have also been made to help consumptives to go overseas for health purposes. It is desirable to give more than the £25 hitherto regarded as a maximum grant in certain specified cases where it is deemed necessary or advisable. Contributions should be sent to the King's Fund for the Disabled, Westminster House, Millbank, S.W. (1) All cheques and postal orders should be crossed.

JAPANESE ELECTRICAL INDUSTRIES.—The *Board of Trade Journal* announces that Japanese electrical engineers have an ambitious scheme to replace the German electricians in the market in China, and, after the war, to contest that big commercial theatre with American and British competitors. Recently a party of Chinese business men and journalists arrived in Tokio in compliance with an invitation from the organisers of the Electrical Exhibition which took place at Uyeno Park. Japanese electrical industries have so far supplied China with electric lamps, wires and cables through their establishments at Shanghai. One of the latest of them has also the supply of these goods in sight. But the opportunity offered by the German withdrawal, and the stoppage of supplies of electrical machines from Great Britain and America is now being seized, and in the Electrical Exhibition the preparedness of Japanese engineers in this new campaign was clearly depicted. According to the latest official census the capital invested in the mechanical industry in Japan is estimated at 180,000,000 yen (yen = 2*s.* 0½*d.* at par), which is principally laid in machine shops and rolling-stock works. The total estimated value of turnovers is 300,000,000 yen a year, and no small part of the figure is in machines. Power supply and electric transportation systems number more than 700, and the capital invested amounts to 600,000,000 yen. The power generated is above 1,000,000 h.p., and the aggregate length of the railways upwards of 1,000 miles. The export from Japan of electrical lamps and apparatus is estimated at 7,300,000 yen a year; Japan was dependent entirely on foreign supplies several years ago. At the Tokio Exhibition almost all departments of the electrical industry were covered, and the exhibitors numbered 227.

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PROCEEDINGS OF THE SOCIETY.

SPECIAL LECTURES.

THE FREEDOM OF THE SEAS.

By Gerard Fiennes.

Lecture I.—Delivered May 2nd, 1918.

In the beginning the seas were free—free from every oppressive keel. Man, so far as we know his history, wandered a happy nomad on plains where he had plenty of elbow-room, where his flocks and herds could graze in peace, and where the only fear of contention was the chance of some dispute with a fellow-shepherd for the right to use a well. Probably he early discovered that a tree trunk or a blown bladder would support him in moist safety on the bosom of the rivers near which he made his home, and, when his wants began to expand, that the river itself was a convenient inclined plane up, or down, which he could transport the wherewithal to satisfy his needs. The estuary gave him fish, and the islands lifting in the distance tempted him to adventure. But the knowledge of the lands and tribes which lay beyond was yet to come.

With growing density of population, however, and the spread of intercourse and knowledge, there came the need for law—the definition and the limitation of primitive right, and the curtailment of personal liberty for the common good. Law demands a policeman, and the strongest or the most cunning was usually accepted as the policeman-in-chief—call him king or Pharaoh. His law ran as far as his arm could reach, and that was to low-water mark on the shore. Beyond that lay the sea, free and lawless, and to it went those who either were lawless, or who would be free.

Greatly daring, they ventured forth, and found what there was to find on the other side. After these first adventurers went the merchant in search of gain. Phœnicians and Greeks who, driven by different causes, took to seafaring at much the same time, met first in Cyprus and entered into relations of mutual trade. They established some sort of law between themselves—for instance, a broken potsherd entitled the holder of either half to hospitality in the land of the other. The stranger had need of the protection of the law on land. But on the sea itself there was perfect freedom and no law. Greeks and Phœnicians each founded colonies—Tarshish, Gadeira in Spain, for instance, and Massalia, where Marseilles now stands. Here the seafaring races first came into conflict. While they traded peacefully at home they fought each other for their colonies, and, naturally, on the sea routes which led thereto. The sea was free—but especially to the stronger. In these contests the Phœnicians, as a rule, prevailed, and became the sea-mercenaries, first of the Persian Empire and then of Alexander the Great.

The seas, then, were free in peace, though, being without law, the peace which prevailed upon them was that of Hounslow Heath while Dick Turpin and his tribe flourished. The freedom of the seas was the freedom of the malefactor as much as of the honest trader. In war the seas were no more free than they have been at any other time in history. The Athenians, under the counsel of Sophocles, cut off the wheat-ships which brought food to the Spartans in the early part of the Peloponnesian War; the Romans held the shortest line of Hannibal's communications with Italy during the Second Punic War; Cæsar fought Antony for the dominion of the world by sea at Actium in the battle-haunted waters where sea-power also decided the fate of East and West at Salamis and Lepanto. It was left to the German of to-day to enunciate the doctrine that the freedom of the seas involves a free path for ambitious

militarism. If this be admitted, the freedom of the seas spells the enslavement of the land.

Passing the early times in hasty review, we come to the age of the Vikings, by no means to be confounded with the Anglo-Saxon settlers on our shores. The Vikings deserved the name of pirates—for a pirate is but an adventurer; and, in later times, such adventurers were even dignified by the qualifying term of "gentleman." The Vikings were gentlemen, though their methods were summary. They enjoyed the freedom of the sea, for there was none to dispute it with them in the northern tracts wherein they sailed. They had their differences with each other; but, although Viking fleets would sometimes fight each other out of sheer sportiveness, these occurred when they harried each other's homesteads, and concerned the land rather than the sea. Alfred, however, disputed their title to that unhampered access to alien shores in which they anticipated the German conceptions of true freedom, and in doing so he laid the foundations of that theory of defence on which the safety of these realms has ever since depended.

Up to this point there has been no trace of a theory of law governing the use of the sea highway. It was the common pathway of the adventurous. Those who used it went armed, though, be it noted, the arms they carried were the arms of the men on board, not of the ship herself. Piracy consisted not in the capture of ships, but in forays on the shore. The daring few alone used the sea, and the only law was the discipline of the ship herself. She was a floating State, a province—as she still is—of the country to which she belonged. This of all the northern seas. The Mediterranean was now a Roman lake, and the oceans beyond were practically unknown to man.

With the break-up of the Roman Empire, however, a different state of things arose. The nations using the sea multiplied. The free use of the great highway was no longer undisputed. There was still no law, and now war rather than peace became the rule—war, even though the countries were at peace with one another. The trading vessel at sea offered a better prize to the pirate than any he could gain from forays on the coasts of the more highly organised States. But as yet piracy was hardly deemed discreditable, and even the vessels of the Cinque Ports, between the calls upon them for the King's service, are believed to have indulged in irregular practices. In the reign of Richard II. valiant John Philpot, Lord Mayor of London, himself equipped and commanded a fleet wherewith he fought and captured a famous Scottish pirate, one John Mercer—for, said he, "We must catch the wasp that stings us and do our best to smoke his kindred from the nest. The nobles who should defend us are laggers and excuse-makers. They do not feel the prick of this thorn as we merchants do, and so they neglect to pull it out. But, an they like it or not, the thorn shall out, and, if they will not attempt it, why, we must."

The history of piracy in the Early and Middle Ages is exceedingly interesting. Kings desirous of sea-power were wont to use pirates as their captains—for pirates, above all others, had the habits of the sea. Ere the Romans left Britain they hired one Carausius, and appointed him Count of the Saxon shore, to ward off the attacks of the Vikings. Carausius seized his opportunity to assume the Imperial purple, and very fine gold coins of his are in existence. He has been claimed as the first of the British sea kings, and elevated to a pedestal as the father of the Navy. But this is romance. He was not a Briton at all; he came from the estuary of the Scheldt.

The great Alfred is also said to have hired pirates to assist his infant fleet. Eustace the Monk, of whom presently, was likewise a pirate, hired to command the fleet of the King of France. Coming down to the reign of Henry VIII. we again find a pirate in command of the French fleet—one Prégeant, called by the English "Prior John." He was the hero of the strange episode in which the English admiral, Sir Edward Howard, lost his life in Brest Harbour. The story is told by Mr. Ernest Law in his book, "England's First Great War Minister."

In such strange ways was the "Freedom of the Seas" maintained till comparatively recent times. Seafaring was a profession almost divorced from life ashore.

The freedom of the sea, however, was "impeached," to use the Elizabethan term, only by pirates in time of peace, while in time of war sea-fighting was between what we may call the armed transports carrying armies from shore to shore—for example, the sea battle between Hubert De Burgh and Eustace the Monk off Dungeness, the Battle of Sluys, and the Battle of Espagnols-sur-Mer, fought off Winchelsea by King Edward III.—at least, so far as the Channel and North Sea were concerned. In the Mediterranean it was different. As against pirates we begin to get the faint

glimmerings of a law at sea. Edward III., after the Battle of Sluys, claimed the title of the King of the Seas, and first exacted the salute from all foreigners, which afterwards led to the first Dutch War. As a price of their acquiescence in this acknowledgment of sovereignty the Hanseatic merchants, Flemings and others, who used the seas for trade, intimated to him that they looked to him to keep a passage for their ships free from the depredations of pirates. "The Sovereignty of the Seas" was thus made to carry with it the first obligation of all sovereignty—the preservation of law and order.

In the early fourteenth century the Hansa rose to power in the Baltic and North Sea. According to the custom of the Phœnicians in early times, and of the Dutch and English afterwards, the Hanseatic merchants established trading houses in the countries with which they carried on commerce. Here the goods were collected, and hence they were borne in the ships of the League. Their great staple, however, was the herring, at that time so plentiful in the waters of the Sound that the shoals were said to have lifted boats out of the water. The Hansa claimed a monopoly, which the Danes disputed, and this led to a confused series of wars which were ended by the Peace of Stralsund in 1370. Here we find the principle of the freedom of the seas distinctly challenged, and the principle that the Baltic should be *mare clausum* of the Germans asserted. It is noteworthy that the Hansa laid down the principle that "enemy ships make enemy goods and enemy goods make enemy ships"—which is the precise opposite of the principle which the modern German would fain establish.

After the Peace of Stralsund, the Hanseatic merchants—or some of them—took to unabashed piracy. They founded societies, known as "The Equal Sharers" or "The Victualling Brothers," and their dictum was turned to their own confusion, for a large Hanseatic fleet, returning from the Bay of Biscay, was captured by the English; while, on another occasion, no fewer than 108 ships were seized by a fleet fitted out by the east coast ports. This latter event occurred in 1451. The practice of seizing merchantmen as an act of belligerency was thus established. Belligerency, moreover, became the normal condition at sea.

In the Mediterranean the freedom of the seas was altogether lost between the eleventh and the sixteenth centuries or later. For this there were three reasons: the rivalries between the three republics of Venice, Genoa, and Pisa for the monopoly of the trade of the Levant; the Crusades, which called upon the resources of the three republics for sea-transport; and the establishment of the Turkish power, followed by the rise of the pirate Barbary States of Tunis, Tripoli, and Algiers. The Venetians, indeed, claimed the Adriatic for their own, and the Genoese the Tyrrhenian Sea. Here we find an application of the doctrine of the *mare clausum*. But once the foot of Italy was cleared, the open Mediterranean was held *mare liberum*, subject only to the monopolies claimed in Levantine ports. It is impossible to do more than touch on this subject. The history is confused; but, in brief, it may be said that the Middle Sea was a theatre of rivalries, and that, if one argosy of a fleet got safe to port, the merchant was a lucky man. The case of Antonio, as given by Shakespeare in "The Merchant of Venice," was no exceptional one. Venice, however, prospered at least in the earlier days owing to the foresight of the Doges in maintaining a war navy to protect her merchantmen. The seas were, indeed, free—as free as the freebooter!

To give an instance of the looseness with which obligations on land sat upon those who followed the sea. In 1099, Baldwin, King of Jerusalem, applied to Venice for assistance, and the Doge, Vitali Michiel, got ready an expedition which sailed for Rhodes, where it wintered. A bloody quarrel immediately broke out between the Venetians and the Pisans. The Venetians were victorious, but restored to the Pisans all the ships and prisoners they had taken, on condition that the latter pledged themselves to trade no more with the Levant This done, the armaments of the two Christian Republics sailed off amicably together to the Holy War. The merchant princes of Venice could be trusted to remember that "business is business." The Venetians lived by trade; and successful trade at this time and years later was thought to require, not only safe communications by sea—which it unquestionably does—but also monopoly in the trading marts, a doctrine not overthrown until British supremacy was established and British policy showed the more excellent way.

By the middle of the fifteenth century affairs had reached an *impasse*. Freedom without law had borne its inevitable fruit. It had resulted in the liberty of the strongest to work his will: the liberty of the wolf among lambs, or of a

dogfish in a shoal of herrings. The first attempt to evolve order out of this chaos by imposing law at sea was made by that model ecclesiastic, Pope Alexander VI. Bartholomew Diaz sailed round the Cape of Good Hope in 1486, and in 1492 Columbus, as emissary of Ferdinand and Isabella of Spain, discovered the Bahamas. In order that the scandal of the Crusades might not be repeated, and that Christians might not fight each other for the privilege of bringing the heathen into the bosom of Holy Church and the gold of the heathen into the coffers of their monarchs, Alexander magnificently divided the Atlantic by a line down the centre. All to the east (and Brazil to the west) was the sphere of Portugal; all to the west (with the exception of Brazil) was the sphere of Spain. For the first time then the ocean acknowledged an owner—so far as a Papal Bull could bring such a thing about. The Powers of Christendom, to the extent that they were interested in the matter, bowed to the decision of the Sovereign Pontiff. Five years later Henry VII. issued a remarkable licence to John Cabot and his sons. It ran:—

"Henry, by the Grace of God King of England and France, Lord of Ireland, to our trusty and well-beloved subjects, Greeting:

"Be it known to all that We have given and granted, and by these presents do give and grant, to our well-beloved John Cabot, citizen of Venice; to Lewis, Sebastian and Sanctius, sons of the said John, and to their heirs and deputies, full and free authority, leave and power to sail to all ports, countries and seas of the East, of the West and of the North, under our banners and ensigns, with five ships of whatsoever burthen and quality they shall choose, and as many marines and men as they will take with them in the ships on their own proper costs and charges, to look out, find and discover whatsoever isles, countries, regions or possessions of the Heathens or Infidels, wheresoever they be, and in what parts soever of the world, which before this time hath not been known to all Christians."

Notice how carefully compliance with the Bull of Pope Alexander VI. is safeguarded. The Cabots are to sail north, east or west, but not south; they are only to look out, find, and discover those "isles, countries, regions, or possessions" of the heathen which were not at that time known to Christians. The purpose of the Cabots was to discover the north-west passage to India, as Willoughby afterwards set out to discover the north-east. It was obviously intended that they should cease their endeavours at the point where they came in contact with Spaniards or Portuguese who had reached the same districts from the south.

Then came a change. Henry's son cut loose from Rome, and the adventurers of England added to the joy of "singeing the King of Spain's beard" the duty of striking a blow at the monopoly granted by the Papacy in the name of the Reformation. Time forbids that I should re-tell the story of Drake and the other great sea-captains of Elizabeth's time. But it is of importance to recall an incident. Mendoza, the Spanish Ambassador, protested to the Queen against Drake's impertinence in daring to sail in the Spanish Main. Said Queen Elizabeth in reply: "Tell your Royal master that a title to the ocean cannot belong to any people or private persons, inasmuch as neither nature nor public use or custom permitteth any possession thereof." The freedom of the seas was thus asserted. They could belong to none, and none could grant monopoly of their use. But that this dictum did not extend to a claim that all should use the sea for every purpose, whether for peace or war, is shown by the action of Elizabeth's captains, who seized sixty ships of the Hansa in the Tagus harbour during the Armada campaign, on the ground that they were trading with the enemy. To use the words of the Book of Common Prayer, the sea was free, but only to those who were upon "their lawful occasions." Whether the occasions of Drake and Hawkins were "lawful" is, of course, a point about which it was possible to hold two opinions, and Mendoza chose his ground badly when he protested against Drake's presence in the Spanish Main rather than upon his proceedings there—which might have proved less easy to justify.

After the spacious times of Elizabeth, many a prime English seaman was discharged and took to piracy. Some even entered the service of the Barbary States and became "Sallee Rovers." Perhaps they but little bettered the example of their captains. At any rate, it may be said that the English, by overthrowing the tyranny of the Spaniard, had upset the law established by Alexander VI., and, in a time of temporary weakness, reaped the consequences. James I. offered pardon to any who would abandon his ways. "I have no intention of obeying the orders of our King, when I am, in a way, a king myself," said haughty John Exton, one of the most notorious of the pirates. James was fain to let the Dutch root out the buccaneers, even from Irish harbours. There was as yet no Power strong

enough to police the seas in the interests of humanity, and freedom still wore the cloak of maliciousness.

The curious topsy-turvydom of the sea affair in the reigns of the late Tudors and early Stuarts is seen by the position of the Dutch. After Amsterdam was "founded upon the herring," for eighty years the people of Holland were engaged in a bitter struggle with their masters, the Spaniards. But the latter were also in conflict with the English, and trade from the Americas in Spanish ships was unsafe. The Dutch and English, though there was no formal bond, were fighting in the same cause, and Dutch ships were immune from English capture. Thus it came about that the very gold for the King of Spain's treasury was brought in Dutch ships. The burghers of Holland grew rich. They established themselves also in the Portuguese trade with the East, thus annulling the Bull of Alexander VI., and became the toughest rivals the English have ever met at sea. The ostensible cause of the series of struggles which lasted through the times of the Commonwealth and of King Charles II. need not be traced. The underlying cause is summed up in the blunt words of Monck: "What matters this or that reason? What we want is more of the trade that the Dutch now have." The era of trade wars had now definitely begun. But the term needs explanation. It was not that the right of any nation to trade by sea was denied, except in so far as the Spaniards denied it in the Spanish Main, but that each nation possessing oversea colonies desired to preserve the monopoly to itself, and, further, to secure the valuable position of "the waggoners of the world." The Navigation Acts of Cromwell and Charles II. were framed to secure the first object, and they were the real, if not the ostensible, cause of Dutch hostility. The determination of Britain that British colonial goods should only be conveyed in British bottoms, manned by two-thirds British crews, struck directly at the position of the Dutch as "waggoners." Britain prevailed by reason of her geographical position, and the circumscription of Dutch sea-power destroyed their reputation as safe "waggoners." This, with the pressure of continental foes on the land side, reduced Holland from her position of supremacy, though her maritime position continued, and is to this day, respectable.

The freedom of the sea without law, and law on the sea without freedom, had thus both alike failed to secure the right of the nations to the use of the great waters. Monopoly was claimed, and continued to be claimed, though, be it repeated, it was rather monopoly of the ports than of the way thither. That, however, soon passed into the claim to "impeach" the intruder in the easiest way—that is, upon the high seas.

The peaceful administration of Walpole in the reign of George I. was disturbed by the War of Jenkins's Ear. The origin of the dispute is instructive. The British had obtained the right to send a ship a year to trade in the Spanish Main. The licence was liberally construed. It was the custom to load the ship on the side which lay along the quay, and immediately to unload the cargo into the ships which lay on the other side of her. Other illegal practices prevailed, with the connivance of the Spanish colonists, who, except for the contraband traffic, were bound by the Spanish system which permitted them only to ship goods to a single port in Spain. Preventive measures in the ports would, obviously, have been useless, in face of the sympathy of the inhabitants with the *contrabandistas*. The Spanish *garda costas*, therefore, were in the habit of capturing what ships they could on the high seas. Among others, they captured Mr. Jenkins, and, as he alleged, cut off his ear, sending him with a message that if his Royal master ventured into the Spanish Main they would serve him the same. Jenkins pleaded his cause at the Bar of the House of Commons, and his story set England aflame, especially his answer to the question what he did under the distressing circumstances which beset him: "I commended my soul to God and my cause to my country." Britain threatened war on Spain. The struggle was speedily merged in the greater conflict of the Austrian Succession. But the people felt that they were fighting for the old cause of the freedom of the seas. Whether this was, at that time, meant to include the freedom of the ports must remain doubtful.

The next eighty years were years of almost continual war; indeed, the war was continuous on the sea, though there were short and troubled intervals of peace on land. France and Britain, with Spain as an intervener, fought for the sovereignty of America and India. The war in the distant possessions, especially in India, went on even while the home countries were nominally at peace, and the trade was held liable to capture unless it could defend itself. The mercantile system was at its height. The monopoly of each country with its colonies was jealously guarded, and, as a consequence, smuggling, with

the connivance of the colonists, was rampant. This was especially the case with the West Indian Islands after the independence of the United States was acknowledged. The ex-colonists did not easily reconcile themselves to exclusion from the privileges they had previously enjoyed as subjects of King George, and Nelson's early services as a captain were largely spent in endeavouring to suppress the illegal trade which sprang up.

Under these circumstances, it cannot be alleged that the freedom of the seas was maintained. Each country, claiming that its ships were part of its territory, applied its municipal law. Thus, towards the end of the eighteenth century, it was established that a slave was free, once on board a British ship, since Lord Mansfield, in the year 1772, in the case of the negro Somerset had decided that no man could be a slave on British soil—and this while the Assiento clause of the Treaty of Utrecht, giving Britain the monopoly in the slave trade between Africa and the New World was still in force. One interesting light is shed on the ideas which prevailed by the legal fiction that all crimes or causes which arose on the high seas were committed or arose "in the County of Middlesex."*

"Freedom of the seas," then, in time of nominal peace, was the freedom of the stronger only. There was latent war; there were countless regulations against smuggling which led to captures, and trial according to the municipal law of the captor; and there was the piracy of the Barbary States and of individual adventurers which the nations made no concerted effort to suppress. The idea of free and regulated intercourse of one nation with another hardly existed. Each, in fact, claimed a monopoly along its own trade-routes, and every other nation contested it.

In time of war a code of law or custom was maintained. At first it may be doubted whether it was generally held that enemy goods in neutral bottoms were capturable. But when the French who, up to then, had been stubborn upholders of the mercantile system, began to ship the produce of their colonies to France in neutral bottoms, then the British were quick to maintain that sauce for the peace goose was sauce for the war gander, and that, as the goods would have been unquestionably capturable in French ships, they could not be rendered immune by transfer to neutral bottoms. Hence arose the famous "Rule of 1756," which is the basis of all our Orders in Council and Prize Court regulations. This Rule, when applied in the War of Independence, gave rise to the first armed neutrality of the northern Powers, and brought in the Dutch against us. It has had momentous consequences in all naval history since. Re-introduced, with modifications, during the Napoleonic wars, it was extended so as to ensure that every neutral ship plying to a European port under the control of Napoleon, should first pay tribute to Great Britain. Napoleon, on the other hand, tried to exclude all goods which had a British taint from the Continent, but with small success. Be it noted, that the principle of mercantile blockade at that era was the precise reverse of that which obtains in the present war. The Continent tried to ruin Britain economically by shutting out her goods; Britain tried, and successfully, to get all the goods she wished into the ports of the Continent, both her own, and those of foreign States which had paid her a toll.

After 1815 Britain was unquestionably supreme at sea, and she set about her great work as law-giver and policeman. She was left with an unrivalled chain of maritime stations in her hands, and these she greatly increased during the years of European peace. The age of steam helped her, since she possessed almost a monopoly of steam coal. Other maritime nations became dependent upon her, and she opened her ports freely to them. She sold them ships, and she employed their subjects as crews for her own. Not only so, but she also used her naval strength and freely spent her wealth to suppress piracy and the slave trade; to survey, chart, light, and buoy the fairways of the world. Freedom and law were at last met together, under the ægis of the one State which possessed supreme sea-power, and used it for the good of the world. The small maritime States, Holland, Norway, Sweden, Denmark, and Greece, flourished under the *Pax Britannica*. They needed no navies to protect their commerce; such protection as was necessary was at our charge. There was no altruism in this; it served our ends.

Turning from peace to war, it was our habit throughout the nineteenth century to regard ourselves not as a belligerent, but as a neutral with the greatest maritime interests, and the agreements we signed, such as the Declaration of Paris, 1856, had our interests as a neutral in view. Free ships were to make free goods; neutral goods were not to be capturable in

* This "floating island" theory is strenuously denied by many jurists, who point out that Statute Law does not run at sea. Perhaps it should be said that the Common Law of each country prevails until it is suspended by international convention or agreement. That is to say, that when a law of the sea is required and there is no law, the most convenient substitute is applied.

enemy ships; blockade to be valid must be effective; privateering is, and remains, abolished—and so forth. The petty squabbles of lesser mortals were not to disturb our Olympian aloofness.

Then came the war, and the freedom of the seas which we had established and preserved was challenged by a nation of inferior sea-power in a novel way. The phrase was adopted as a catchword by our enemy, who, at the same time, was violating the thing itself in every conceivable way against both the law and comity of nations. What the Germans mean by the freedom of the seas is obscure. But the end and purpose of the German demand seems to be that the maritime nations shall be left helpless in the clutches of an ambitious land Power. Not only is a Continental belligerent to receive all the comfort and succour which can be sent from oversea, but he is to have the right also to send his transports unchallenged until they reach low-water mark on the coasts of his enemy. The barrier between free mankind and tyranny is to be done away; the sea is no more to be "as a moat defensive of a house" behind which—or, rather, behind the fleets which guard it—nations may develop their life free from the burden of conscript service, but is to be a highway for the passage of armies unscathed by the resistance which would meet them on shore, or which, at present, would make their passage by sea perilous.

Germany makes little secret of the fact that what she seeks is freedom of the seas in time of war, in order that the greatest obstacle to her lust of world-domination may be removed. For peaceful commerce the seas are free, thanks chiefly to the work of Britain. Germany, who has proved that she possesses the morals of a pirate, seeks to re-establish in an aggravated form the freedom of the malefactor.

Whether, in some future blissful condition of the world's politics, there may emerge a Law of Nations extending to the sea as well as to the land, the future must decide. Up to the present, law has been coincident with territorial possession, and the true freedom which goes with law-freedom—that is, for strong and weak, great and small alike—has only been secured when one country was strong enough to make its ideals prevail at sea. In any other sense, we shall only secure "Freedom of the Sea" when the federation of the world is an accomplished fact. And then the era of war will be at an end. In peace, no greater freedom is possible than was maintained during the reign of Britain between 1815 and 1914.

INDUSTRIAL DEVELOPMENT IN INDIA DURING THE WAR.*

By D. T. Chadwick, I.C.S.,
Indian Trade Commissioner.

(*Continued from p.* 658.)

In the range of metals, the importance of the Indian deposits of mica, wolfram, and chrome are well known, and the workings of these have all been extended. The opening of the large Bawdwin deposits by the Burma Corporation should supply large quantities of lead, silver, zinc concentrates, and copper. The output of this Burma pig-lead, which is of high grade, already equals approximately India's pre-war needs. Tin deposits have very recently been reported from the Thaton district, near Amherst, in Burma. With the iron and coal resources of India now being actively opened out, and with non-ferrous minerals also being commercially worked, there are better prospects than have hitherto existed of India having available those metallurgical resources which are vital to all industrial development, and which hitherto she has lacked. The manufacture of the alloys of iron has commenced, with that of ferro-manganese. A set of electric furnaces is also being erected at Sakchi, primarily for refined steel for springs, tools and other purposes, but should occasion demand, these also will be devoted to making other ferro alloys, *e.g.* ferro-chrome, ferro-tungsten, etc. Concurrently and inevitably with these developments and needs engineering shops in India have been enlarged and new ones started. But they, and in fact practically all these industrial efforts, have naturally had to contend with the greatest difficulties in obtaining machinery and equipment.

Furnaces, works and factories cannot, however, be built cheaply without local supplies of structural and refractory materials. Structural steel is now available in considerable quantity, and will be forthcoming in the future still more largely; whilst the capacity of works producing cement of British standard quality has, during the war, increased from about 5,000 tons to some 70,000 tons, and further developments are certain. Among refractory materials a beginning has been made with silica bricks claimed to be equal in quality to those of England or Japan, and large quantities of these will be needed. The magnesite deposits in the Madras Presidency are of a high purity. The manufacture of

* Delivered at the British Scientific Products Exhibition, September 3rd, 1918.

magnesite bricks is thus sure to follow. Though Indian asbestos appears totally unfit for textile purposes where flexibility is of great account, it may yet prove suitable for boiler-lagging and fire-proof compositions. Thus some of the first steps for developing locally the metallic resources of the country have been taken. But this is an age not of iron alone, but of iron and chemistry. And perhaps it is in regard to the supply of some of the primary chemicals and in the solving of chemical problems connected with Indian industry that the greatest difficulties for advancement lie. One of the first difficulties is to ensure an adequate supply of cheap sulphuric acid, of which at present the local production is small, though this should become possible if the Burma zinc concentrates are smelted in the Bengal Presidency.

Another basal chemical which is not yet produced satisfactorily locally is caustic soda. Among ammonium salts, sulphate of ammonia is obtained at present chiefly as a by-product from the coke ovens. When one turns to the large number of derivatives from coal tar, one is met by the unfortunate fact that the yield of tar and acid constituents from Indian coal is as a rule low, only being 2·1 per cent. as compared with 4 per cent. in Great Britain. The possibility of developing local resources for aluminium and calcium carbide, cyanamide, etc., turns on the supply of cheap electric power from the waterfalls of India. Electric power has already been supplied successfully to industry in India on a limited scale. The two best known cases are those at the Cauvery Falls in Mysore, chiefly to supply power to the Kolar goldfields, and the more recent Tata hydro-electric scheme for supplying Bombay. In the first of these the capacity of the power-house at present is 22,650 electric horse-power, and in the second 100,000. Both are being extended. But for these basal chemical and metallurgical industries still cheaper sources of power are required, and the Tata interests have investigated a proposal for throwing a dam across the Koyna River in the Western Ghats, whence 300,000 horse-power per hour will be obtainable throughout the year. It is certain that the possibilities of the use of water-power in India for applying electrical energy have by no means been exhausted, and with their further exploitation a development of some of the industries based on a supply of cheap electric power can be expected. Apart, however, from these chemical industries, the inception of which depends on the existence of cheap power, there is a large number of chemical problems associated with industry in India waiting solution. One of the activities of the Munitions Board has been to "mobilise" the chemists at present in India, and allocate to them specific problems for solution. Hitherto, except in a few cases, chemists in India have been mostly employed in the educational departments scattered throughout the colleges of India, and, generally speaking, have not been in touch with industrial problems. Full advantage has thus not always been taken of their knowledge and training. In this respect India does not stand alone. This knowledge and talent is now being utilised. In every case they have to work with and on substances available in India. A few of the items of research allotted to different chemists may be cited as indicative of the class of work undertaken. Such are colloidal medicinal preparations, the causes which render bleaching powder unstable in hot climates, the preparation of suitable chromate by extraction from chrome iron ore without the use of caustic soda or sodium carbonate, the fire-proofing of gunny cloth, the purification of nim, gingelly and Indian fish oils, indigenous sources of tartaric acid, the refining of waste copper, the refining and preparation of several of the essential oils, varnishes, methods to prevent the deterioration of turpentine oil under storage, the dyeing of skins, furs and tussar silk, the isolation and cultivation of the specific yeast associated with mahua flowers, etc., as well as the manufacture of acetone by the fermentation process for which at present the most satisfactory material from a technical and economic point of view appears to be cholam or jawari—the larger millet. There is, however, one product associated with a historical and romantic Indian industry which is on exhibition in this building—in Section XII.—which illustrates the co-operation of planters, business houses, Government, and scientists in India and England. I refer to indigo—an article which appears in the earliest shipping lists of the old East India Company, away back in the seventeenth century. This is no time to dwell on the serious competition from which indigo has suffered. The war caused a great and sudden revival of interest in it. This opportunity has not been treated as a mere chance for recovering some earlier losses; it has also been utilised for serious organisation and

definite research work, in which the Behar planters, the Government of India, and a strong scientific and business committee in England, in which Professor Armstrong takes an active part, are all co-operating with the double object of increasing the outturn of indigo per acre, and also of putting the final product on the market in the form of standardised paste. Work on all crops takes time. The seasons are inexorable; but progress has been made, and none except perhaps a most aggressive chemist, if such there be, will fail to wish success to these efforts to preserve for the world the finest of all vegetable dyes, and one which at its best is generally admitted to possess certain qualities lacking in synthetic products.

It may seem strange, when speaking of a land of rice and wheat, to allude to new food-stuffs. But the exigencies of war have turned attention in India, as elsewhere, to food. Samples of malted foods from Indian cereals have been prepared, and from Bombay comes the report of a purified ground-nut flour of considerable nutritive value, and not dissimilar from the cotton-seed flour which in this country has been recommended as a suitable diluent for wheat. Indications seem to point to the likelihood of testing thoroughly the possibility of jam-making in certain parts of India.

In this brief summary an effort has been made to sketch some of the main outlines of the new industrial developments in India during the later years of the war. The largest contributions in material goods have naturally been made by the large and varied textile industries extending over a wide range of articles, from khaki cloth and turbans to blankets and coir screening. And to supplement the efforts of the mills, many of the hand-loom weavers have been employed on tasks within their capacity. The feasibility of employing the old indigenous craftsmen of India has thus not been neglected, though obviously it is more difficult to ensure working to specification by them than by the large mills. The mere enumeration of the articles made in these various branches of textiles would exhaust all the time allotted for this lecture. So it has been deemed preferable to concentrate attention on what are, perhaps, the less widely-known industrial efforts in India, and to mention some of the difficulties they have had to meet. Frequently work has had to be done with makeshift apparatus and machinery, and it must not be supposed that every effort mentioned in this lecture will ultimately blossom into a large successful industry. Some wreckage there is bound to be when the period of transition comes. In endeavouring to summarise in thirty minutes a wide field of endeavour and activity, it is difficult to avoid causing, perhaps, a too roseate impression of progress. Anyone who knows India realises that there are difficulties ahead when full competition again becomes operative, but some solid progress has been made; and I hope that this brief sketch does show that there is a wakening spirit abroad to industrial possibilities in India, and also that there is a strong hope of effectively widening the basis of industrial employment in India. Most industries are in some ways interdependent, and in diversity is to be found strength. Such diversity India, before the war, lacked. The attaining of it in war time when machinery was especially difficult and costly to obtain, and finance always a problem, has been and remains a difficult task; but it was the stress of war which showed clearly the vital need, and also gave the stimulus to joint and organised effort, and which has also shown that with well-established, well-managed industries, India can be an added source of strength to the Empire in general.

One of the greatest needs of the immediate future is for more organised practical scientific research into the industrial resources of India, both in forestry, mineralogy, hydro-electricity, and in industries themselves. In the more thoughtful circles in India this is generally recognised.

In spite of this progress, which all good wishers of India desire to see maintained and increased, India will continue for long to be mainly an agricultural country, and the change to industrial pursuits will only affect part of her population, of which at present a disproportionate section are still dependent on agriculture. Some Indian industries have often been criticised on the ground that employers have paid insufficient attention to the conditions under which the workmen labour and live. This must not be accepted too sweepingly. The more far-seeing business leaders of all communities are interesting themselves in welfare work, in schools and housing, realising that only by such means can labour become interested in factory work.

This is not a full account of India's economic effort during the war. That obviously cannot be given yet. We do not yet know how far we may be led. In fact, cables received last week

show that another phase is opening, with the orders to make standard cotton cloths at controlled prices—the counterpart in India to the standard suits of England. The repercussions of this war are worldwide, and the problems to which it gives rise present in most countries certain broad lines of similarity, though the conditions in which solutions for such problems have to be sought are widely different. Finally, I wish to repeat and emphasise that this lecture is merely a summary of some of the main lines of Indian industry during the war; it is in no sense an economic survey of India in war time. As in every other country, some have made great profits, other large classes have suffered loss. There is such widespread talk nowadays of raw materials, that the impression easily grows that there must be unlimited markets for all India's raw produce. Such is not the case. Difficulties of transport and finance weigh as heavily on India as on other countries. For instance, the area under cultivation of such a war commodity as jute has decreased since peace time, whilst the markets for some other crops have greatly shrunk. As elsewhere, some in India have lost, some have gained, by the economic dislocation caused by war. How the balance will come out in the end remains for future study to disclose.

INDUSTRIES AFTER THE WAR.

III.—Electrical.

In the general survey with which the weighty report of the Departmental Committee on the electrical trades is introduced, it is urged that the national importance of those trades has never been realised either by the Government or the general public. Through the achievements of Faraday, Wheatstone, Kelvin, Swan, Hopkinson, and many others, Great Britain was first in electrical enterprise, and should have retained her pre-eminence; but manufacturers were hampered while Parliament and local authorities debated how the distribution and use of electricity might be prevented from infringing "conventional conceptions of public privileges and vested interests." Consequently foreign manufacturers were enabled, both in their own and other markets, to gain a hold which they have never lost. The approximate annual value before the war of the total products of electrical plant, mains, and appliances in this country and in Germany is set out in the following table:—

	Great Britain. £	Germany. £
Total electrical products	22,500,000	60,000,000
Exports	7,500,000	15,000,000
Imports	2,933,000	631,000
Consumption of *home-made* machinery . .	15,000,000	45,000,000

Moreover, of the £22,500,000 manufactured here, a large proportion was produced by concerns under foreign control, and in the case of "British" exports a proportion consisted of foreign manufactures reshipped as British goods! Apart from legislative obstacles, Great Britain, it must be remembered, had attained much prosperity and technical efficiency in her use of steam, and therefore her manufacturers had less inducement than their rivals in foreign countries to adopt electrical driving. Another factor retarding our electrical progress has been the "strength of the gas interests." Again, foreign Governments, appreciating the importance of conserving their home markets as a basis for the development of overseas trade, imposed protective duties and exerted influence on State Departments to purchase native goods. An industry cultivated under these and other encouraging conditions has had an immense advantage in international competition. There is, the Committee says, conclusive evidence of the existence of German control over companies ostensibly British, and of that German control being exercised to the detriment of British interests indirectly through companies incorporated in America, Switzerland, and other neutral countries. "At the outbreak of war negotiations were in progress for the acquisition by Germany of financial control in existing companies of the United Kingdom, as well as in the British Dominions and India, which if successfully concluded would have still further restricted the use of British goods in many parts of the Empire."

The scientific replanning of our distribution of energy on which the Committee so strongly insists would, it is calculated, effect a saving of no less than 50 million tons of coal per annum. Witnesses of high authority estimate the loss incurred by the nation through failure to take full advantage of electrical progress at quite £100,000,000 a year.

The larger part of the report is devoted to a careful and detailed examination, from sectional points of view, of the position of the industry. Section I. deals with electricity generation and transmission; Section II. with electric traction; Section III. with manufacturing; Section IV. with the interdependence of manufacture and finance; and Section V. with Imperial control of sources of electrical energy. Respecting the latter, it is suggested that, in particular, India and the self-governing Dominions should take stock of their facilities for generating electricity, whether from water-power, coal, oil, or other sources of energy, and should appreciate their permanent and ever-increasing importance to the Empire.

The Committee concludes by making the following recommendations:—

"(1) Thorough reform of the legislation and conditions under which the generation and distribution of electricity are promoted and administered in this country; and a like reform affecting the promotion, construction, and operation of tramways and light railways. (2) Prohibition of import of

enemy goods for three years after the conclusion of peace, subject to importation under licence in special circumstances after the expiration of the first twelve months. (3) Imposition of import duties sufficiently high to protect effectively the electrical industry. (4) Prevention of the sale in the United Kingdom of any imported electrical goods at prices lower than those current in the country of origin. (5) Recognition of the advantage of combination among manufacturers and official co-operation with such action. (6) Prevention of any concern engaged in the electrical or allied manufacturing industries, if controlled directly or indirectly by enemy capital, from continuing to trade within the Empire, unless it be specially authorised and its constitution made public, and the passing of legislation requiring that not more than 25 per cent. of the capital in any other electrical or allied undertaking shall be held either directly or indirectly by enemy subscribers or their agents. (7) Treatment as enemy products of all goods produced in foreign countries by concerns controlled by enemy capital or under enemy direction. (8) Exclusive acceptance of British tenders by State Departments, public bodies, and companies supplying electrical energy under statutory powers. (9) Adoption by Government Departments and public authorities, so far as is practicable, of standard types and patterns of plant and apparatus. (10) Prohibition of transport discriminations operating to the detriment of British manufacturers, and the provision of improved transport and cargo-handling facilities. (11) Promotion of a better understanding between employers and employed, and the provision of better housing and working conditions. (12) Provision of extended banking facilities, preferably by the establishment of industrial banks, to enable British manufacturers to secure and finance contracts and engineering enterprises. (13) Recognition of the permanent and ever-increasing importance to the Empire of the natural sources of power for the generation of electricity in the British Dominions, and the introduction of safeguards by legislation or otherwise to prevent these national assets from passing into alien hands or under alien control."

The Committee promises a supplementary report dealing, *inter alia*, with education, research, the decimal system, and the consular service.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

On September 7th the British Scientific Products Exhibition was brought to a close after a run of four weeks. The aim which the promoters had in view was to illustrate, by means of the exhibits, the great advance made in the production of articles of prime importance for the home and foreign markets hitherto obtained from other countries, and the successful realisation of that aim reflects the greatest possible credit upon the Organising Committee. To the British Science Guild belongs the honour of having promoted the Exhibition, and of assuming the financial responsibility. It is generally supposed that the project was in some way supported by the Government. That is not the case, for, apart from the remarkable display of the Air Ministry, and some exhibits by the Munitions Inventions Department, and some other optical departments, the authorities have neither supported nor assisted the Committee in any way, except that the Board of Trade loaned some show-cases. An honourable exception can be made in the case of the leading officials of certain departments. The Exhibition was visited by large numbers of the public, who, by their intelligent interest in the appliances shown, completely disposed of the idea that they are indifferent to scientific work and its possible industrial results. If the British Science Guild carries out its intention of holding an annual exhibition of British progress in science and invention, it will be performing a service of the highest national importance.

In the limited space available it is impossible to review the exhibits in detail; for those who were unable to visit King's College there is still available the excellent descriptive catalogue,* with its useful articles on recent developments, which will serve as a reliable guide to the progress achieved in scientific industries since the outbreak of the war. The exhibits covered a wide range, and included chemical products and processes, physical and electrical appliances, optical apparatus, measuring and mechanical instruments, surgical, bacteriological, and pathological appliances, including X-ray apparatus, etc. In practically all the sections the degree of progress indicated by the exhibits was surprisingly great, and even where no striking development has occurred in the way of new invention, there was noticeable a marked general improvement in apparatus constructed on the recognised lines of pre-war days.

Interest naturally centred round those exhibits associated with aircraft production. Here the developments and the differences between present-day aeroplanes and those of a few years ago were clearly marked. Modern spars, for instance, are much stronger for a given weight, engines have been developed, both as regards the material and construction, to the extent of reducing their weight by more than one-half, whilst the size and power have grown enormously, and are still making advances. The materials which have been produced since the outbreak of the war, and of which aircraft constructors have been able to avail themselves, have made it possible for the greater part of an aero-engine to be made of light alloys. In non-metallic materials the investigation of timber has led to some interesting results. With regard to the many fittings which go to make up the complete aeroplane, one item of outstanding interest is the magneto. Before the war the Germans had practically a monopoly in the

* London: The British Science Guild, 199, Piccadilly, W. (1) pp. 268. 2s. 6d. net.

manufacture of this article both for car and aeroplane use, the Bosch magneto undoubtedly being the most popular throughout the world. The war has changed that, and the British manufacturers have seen to it that the home-built magnetos are worthy of their name. This is a very striking instance, and is a most promising augury of future trade. There are now nine British firms engaged in this work, with the result that during the past four years 300,000 magnetos have been manufactured for war service alone. What is equally important is that the home-made magneto is now as good as, or even superior to, the previously imported Bosch machine. The development of dope for the fabric of aeroplanes has been the subject of many investigations, and the planes of the present-day machine are rendered taut and weather-proof by means which, though slightly more complicated than varnishing, are many times as efficient. The British dopes consist of a solution of cellulose acetate made from paper or some cheaper form of cellulose, or of gun-cotton dissolved in suitable solvents and diluted in order to reduce the solution to a workable viscosity.

During the war much progress has been made in the manufacture of insulation and of resistance wires, both of which were largely imported from Germany. The same is true of electro-medical apparatus. The examples of these displayed at the Exhibition showed that British manufacturers are capable of supplying our needs and of producing thoroughly sound products. We may pass over the interesting display which furnished a fine example of successful British production on scientific lines of instruments of a high standard, and of the exhibits of refractory materials, in which direction progress has been very marked during the past four years. This is another industry which has been captured from our enemies, and which there is very little likelihood of their ever recovering, for with proper care British manufacturers should be able to maintain their positions in this trade after the war.

Before the outbreak of war lens-grinding machinery was either made by the individual user, or imported from abroad. Now such machinery, at least equal to any imported machines, is available in sufficient variety to cover all the ordinary types of work. At the same time, entirely new methods of working glass have been developed and brought into ordinary use. Some of these methods are particularly well adapted to the manufacture of standardised optical systems. The most striking development in this respect has been the way in which enormous numbers of prism binoculars, sighting and other small telescopes, have been made to meet the demands of the military and naval authorities.

The gradual awakening of the British glass industry since the early days of the war, as revealed by the Exhibition, is a feature which deserves particular mention. The two immediate needs were chemical glass and optical glass. Let it be said, to the credit of British industry, that in regard to optical glass a well-known British firm near Birmingham started the manufacture of this in 1848, and kept it alive at considerable pecuniary sacrifice. Since the outbreak of war its output has increased twenty-fold. Up to nine months after the declaration of war, however, there was no general and active movement among manufacturers to take up new work. Since then steps have been taken to speed up glass manufacture in general, and from the beginning of 1916 the trade has rapidly progressed from a state of dependency or doubt to one of determined optimism. The Exhibition provided some measure of the material results of the re-awakening of the glass industry in this country.

Space does not permit more than a brief reference to the evidence shown at the Exhibition of the development of the dye industry. The outbreak of the war disclosed a dependence on Germany for our supplies of dyes which was little short of appalling. The serious position in which we were placed is evident when we realise that our trade in cotton and woollen goods, as well as the requirements for leather staining and a multiplicity of minor industries, could be carried on only with the aid of these essential materials. Dependent upon the dye industry is that of drugs and fine chemicals, and the evidence of progress in the production of these shown by the exhibits encourages the hope that the Empire is now self-supporting in regard to its supply of these essential materials.

The exhibit of the Gas Traction Committee illustrated the employment of coal gas as a substitute for petrol and petroleum products in motor vehicles, and comprised containers for the gas, meters for measuring the quantity used, cut-off valves, and a standard London motor-omnibus with gas fuel under compression. A different interest attached to the exhibit of the Nottingham Chamber of Commerce, consisting of embroideries. In 1913, more than one and a half million pounds' worth of embroidery was imported from Germany. The industry has been established here for many years, but progress has been slow on account of the economic conditions. An exhibit of hosiery knitting-needles indicated the progress made during the war by one firm, which is now producing more "latch" needles than were made before the war by all the British makers together. About 90 per cent. of the world's needles were made in Germany before 1914, and the cutting off of supplies brought thousands of our hosiery and underwear machines to a standstill. The Bradford Technical College sent specimens to the Exhibition dealing with aspects of technical manufacture in which Germany excelled. Important results have been secured by combining the Continental and British system of worsted yarn manufacture. The cloths produced as a result of this method are said to be equal in all respects to those obtained by using the Continental system throughout.

If the aim of the British Science Guild in organising the Exhibition was to stimulate public

interest and confidence in the capacity of British science, combined with industrial enterprise, to secure and maintain a leading place among progressive nations, it must be admitted that the aim was fully achieved by the representative character of the exhibits displayed.

ARTHUR COHEN.

THE CLOVE INDUSTRY OF ZANZIBAR.

The clove industry of the Sultanate of Zanzibar (including the islands of Zanzibar and Pemba) is a unique example of a valuable economic plant, not indigenous to the country, having been introduced from abroad and developed until it not only became the most important agricultural endeavour of its adopted country, but enjoyed an expansion which gave it the premier place in the world's production of that article. It is stated on good authority, writes the United States Consul at Mombasa, that Zanzibar is the source of over 90 per cent. of the world's supply of cloves, the balance being furnished by the Molucca Islands of the Dutch East Indies and by Madagascar. The value of this product to the Arab planters of Zanzibar averages, roughly, £500,000 annually, the production varying widely from year to year.

Apparently no accurate census of the acreage and number of clove trees of the Sultanate has ever been taken, but using the known statistics of the Government plantations (about 6 per cent. of the total clove area) as a basis, the area actually devoted to the industry is approximately 54,000 acres, of which 36,000 acres are in the island of Pemba. This area contains some 3,700,000 full-bearing trees, planted about sixty-five to the acre, different plantations varying considerably in this respect. The average annual production of cloves per tree for the past ten years is about 5 lb., but every five or six years the production falls, for some unexplained reason, to less than ½ lb. per tree, while in other years it will run as high as 8 lb., or even more.

The trees begin to bud in January or February; picking commences in July or August, and lasts for four or five months. Actual deliveries to the market occur throughout the year, but are heaviest from November to and including February. The marketing abroad is usually done by European firms in Zanzibar, who have specialised in this trade for years.

The crop returns in recent seasons (ending June 30th) have been as follows:—

	Zanzibar. lb.	Pemba. lb.	Total. lb.
1912–13	1,085,630	3,652,880	4,738,510
1913–14	5,095,510	22,333,290	27,428,800
1914–15	6,822,200	11,598,615	18,420,815
1915–16*	4,576,005	21,691,810	26,267,815

* To March 21st.

The extreme variance from year to year may be noted from the above figures. 1911-12 was the largest production year in the history of the crop, notwithstanding that since then a number of young trees have come into bearing. There is apparently no reason for these differences other than the general statement as to the sensitiveness of the tree to even very slight climatic changes. The production of clove stems amounts to 18 or 20 per cent. of the clove crop.

Zanzibar's export of cloves from 1912 to 1915 were:—

To	1912.	1913.	1914.	1915.
	lb.	lb.	lb.	lb.
Europe	6,067,460	8,789,644	5,707,601	9,270,001
America	2,576,520	1,975,518	3,499,917	4,494,299
Asia	6,539,807	6,772,530	7,657,767	11,525,332
Africa	68,157	275,047	105,123	135,822
	15,251,944	17,812,739	16,970,408	25,425,454

India is the largest purchaser, taking nearly one half of the whole crop; the United Kingdom comes next, followed by the United States and France. The cloves are packed in bales of 4 frasilas (140 lb.) each. There is an export duty on this product of 25 per cent. *ad valorem*.

Many years passed after its introduction into Zanzibar before the Arab planters realised that in the clove they had found a valuable commercial plant, which was better adapted to the peculiar conditions of the climate and soil of the Sultanate than it was to its own native environment. Many tropical countries have attempted the cultivation of cloves, but few have experienced any material success. Even along the coastal plain of British East Africa, where climatic conditions are apparently similar to those of Zanzibar, every effort to establish the tree has met with failure. Rainfall, atmospheric conditions, natural drainage, and soil elements, have their bearing upon the successful culture of the clove tree, for it is only when all these factors combine at a certain ill-defined point that the plant will thrive.

Specialised labour also had its influence in maintaining the industry, for it is to be noted that generations of cultivators and pickers, who have known no other employment throughout their existence, have followed one another in the tasks of their forefathers. In no other way, perhaps, could the culture of cloves have been continued,

as the tree and its crop require expert management and handling. Even the financing of the plantations and crops has been carried on by the same firms and their successors for generations.

An all-important factor which has contributed to the success in the establishment of this industry in Zanzibar is the Arab and his ability to control native labour in a way which the European has never learned. Cheap labour, due to the practice of slavery (abolished in 1897), also had its influence. But even now, when the Arab no longer has the authority of the slave-master to enforce his wishes and must pay a monthly wage of about 14 rupees, his intimate knowledge of the native mind, and his patient tolerance of idiosyncrasies, render serious competition from the European a remote possibility. In this respect, also, it is hardly probable that a clove plantation, which requires many years to establish, and when in full bearing cannot be depended upon to produce a gross annual income of more than £9 or £10 per acre per year, would offer any real inducement to European capital and management. It is an industry peculiarly adapted to the temperament and ability of the Arab race. European participation in the business will probably continue to be confined merely to the marketing of the product, the cultivation and harvesting being left entirely in the hands of the Arab planter.

GENERAL NOTES.

British Prisoners of War Book Scheme.—Owing to the recent fighting on the Western Front, which has led to the capture by the Germans since March last of some 90,000 additional prisoners, the requests for books have of late enormously increased, and the authorities are greatly in need of more voluntary workers. The work appeals, more perhaps than that of most other war charities, to educated men and women. If, therefore, any Fellows of the Society can do anything to bring the scheme to the notice of those who may have some spare time which they would like to devote to interesting and useful war work, the Committee would be very grateful. They require regular whole-time or part-time workers to help in the various departments of selecting, censoring, sorting or packing books, and in filing, registration, correspondence, and other secretarial work. Sir Alfred T. Davies, K.B.E., C.B., Chairman and Hon. Director of the Scheme, Victoria and Albert Museum, South Kensington, S.W. (7), will be glad to forward information about the work to any inquirers.

Paper-making Materials.—The general scarcity of paper, in spite of the recent allocation of additional shipping for its importation, continues to invest the discovery of new sources of supply with great interest for manufacturers and traders. Though the present problem is largely one of shortage of ship's tonnage, the steady growth of the world's demands for paper renders it imperative that new paper-making materials should be brought into use if prices are to be kept down after the war. Among the materials examined at the Imperial Institute during the present summer have been grasses from South Africa, the Federated Malay States, Australia, and St. Helena. Samples of "Tambookie" and similar grasses from the Pretoria district gave a high yield of pulp of good quality, capable of conversion either into excellent brown paper or (after bleaching) into white paper. Lalang grass—which grows abundantly in the Malay Estates, and hitherto has been so little esteemed that on the rubber plantations it is regarded as a troublesome weed—was found on investigation to compare favourably as a paper-making material with Algerian esparto grass, though it is not quite so good as Spanish esparto. Bamboo grass from the Northern Territory of Australia came up to about the same standard.

Wasted Power at Niagara.—It is estimated that five million horse-power is being wasted by omitting to utilise fully the Niagara Falls. The annual value of the power going to waste is at least $50,000,000; and, meantime, important works are suffering from lack of power to operate at the full capacity for which they were designed. It is stated that industrial men on both sides of the Falls are anxious for more complete utilisation, and that the only obstacle is Governmental inertia. The proposed consolidation of the Niagara Falls Power Company, the Hydraulic Power Company, and the Cliff Electrical Distributing Company would be followed by expenditure of $15,000,000 on new equipment, and a total increase in output of 170,000 h.p.—*Electrical World* (New York).

Irrigation Canals for Chile.—A new irrigation canal in Chile, the Mauco, has been completed. It has a length of 72 kilometres, and will irrigate 4,900 hectares at a cost of $1,600,000. Two more canals, the Maule and the Lafa, are under construction. The former is to be finished in 1920, and the latter in 1919. Another canal is to be constructed in Melado, of 23 kilometres in length, to irrigate 31,118 hectares, at an approximate cost of $5,194,000. It is also intended to dam the River La Laguna, near Coquimbo, which will store 40 million cubic metres of water at a cost of $100,000; the lakes of Planchón, which will keep 55 million cubic metres, at a cost of $350,000; to dam the lake of Mondaca, to store 70 million cubic metres of water, to irrigate 8,000 hectares, and other canals at a cost of $1,860,000. The Inspectors of Irrigation have under consideration the irrigation of the valley of Petorca with the water of the River Choapa, the damming of the rivers Aconcagua, Tinguiririca, Diguillán, Lake Invernada, and Maule, and the irrigation of the Nilatine valley.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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PROCEEDINGS OF THE SOCIETY.

SPECIAL LECTURES.

THE FREEDOM OF THE SEA IN WAR.

By Sir Francis Taylor Piggott, M.A., LL.M.,
Chief Justice of Hong Kong, 1905-12.

Lecture II.—Delivered May 9th, 1918.

If war were always waged on land, if fighting were no more than a trial of physical strength between the young warriors of the quarrelling nations, the freedom of the sea would remain undisturbed, and traders be left in peace to pursue their lawful avocations. Does this pacifist dream represent the traders' wishes? Frankly, I very much doubt it. To judge by all the talk about the freedom of the sea at this time, you would think it was their heart's desire. I am sceptical, for there is nothing in history to warrant a belief in their altruism. The secret of the whole matter is this: War is good for trade. To provide all the things needed to carry on war is a "lawful avocation." Call it "commerce" if you like; it is those increments of commerce, engendered all the world over by even the smallest war, which the neutral trader seeks to protect. If any one doubts this harsh judgment let him read the documents in which the sordid story is written. You cannot begin to understand the most complex of man's activities, war, nor hope to settle the problems which arise out of it, if you omit to take into account human nature; and money lies at the root of human nature. All the theories that have ever been spun into what is called the "Law of Nations," all the books that have ever been written about it, seem to me to leave human nature out of consideration. War will not be won, nor the peace kept, by theories. There are two facts which govern war—the fighting fact, that men will fight all they know how, and with anything they can lay their hands on; the trading fact, that when war is afoot the merchants will trade with the fighting men for all *they* are worth, and *in* anything they can lay *their* hands on; and the shippers will carry cargoes for them anywhere, and at any risk, so long as high freights are paid.

Wise men have been busy for centuries devising means which shall abolish these evils, or at least restrain them within bounds. They have elaborated two codes of rules. The first is to regulate the fighting and keep the beast in man under control. This code is known as the Laws of War, which—till in this war the beast got the upper hand—seemed to have achieved some measure of success. The other is known rather vaguely as International Law. It had so little success even before this war, to judge by the endless disputes to which it gave rise, both in the Prize Courts and the Chanceries, that it is not surprising to hear the opinion freely expressed that it has broken down altogether. The reason of this disaster is the thesis of this lecture. The theorist began at the wrong end, applied pressure in the wrong direction. He took the trader under his wing, and invented maxims for his protection against the belligerent, oblivious of the fact that they would also protect the enemy. In the development of this thesis, I must open some forgotten chapters of English history, with which at this time it is necessary that Englishmen should be more familiar than they are. England is fighting for her life, to-day with the armies of civilisation on her side. She was fighting for her life then, with all the world against her. It is not much to ask that men should know something of the story of that past.

I first deal with the effect of war on the freedom of the sea. That freedom of peaceful navigation, fishing, and trading, cannot be better described—the sea being the common highway of the nations—than as corresponding to the freedom of the King's highway. But the sea is also, and the memory of man does not

run to the time when it was not, the common battle-area of the nations. One of the purposes of a fleet is to destroy the fleet of the enemy. Fighting at sea is inevitable, and so are brawls upon the highway. And just as those brawls disturb the lawful avocations of peaceable citizens, so sea fights, the brawls of nations, disturb the sea-traffic of those nations which are not concerned with the quarrel. The trade-routes are no longer safe; merchant-ships may find themselves in the midst of a battle; they must set their courses by little circles rather than by great in order to keep out of range of gun-fire; there is a general disturbance which seriously affects our friends the neutrals. Nor is it possible to localise the fighting, restricting it to any specific area of the ocean. The enemy's ships must be fought where they can be found. A war between Japan and Russia might lead to a battle in the North Sea, just as a war between European nations has led to battles in the Pacific and the South Atlantic. To this widespread inconvenience the nations which are not at war are subject, inevitably; and in this large measure, therefore, the freedom of the sea is curtailed by war.

But a deliberate attack on the high sea by a belligerent upon the commerce or navigation of the neutrals, unconnected with any specific battle, would give rise to just remonstrance and compensation; might, if apology were not given and accepted, or if the attacks were persisted in, most justifiably lead to war.

So much depends on the accurate appreciation of this fundamental fact that, going somewhat ahead of my argument, it must very clearly be understood that nothing, not even imminent defeat, would justify seizure of neutral vessels trading on the high sea between one neutral port and another, far removed from the normal area of the fighting, not even though the cargoes taken from them might serve to turn the scale in favour of victory. Yet even in such circumstances, which, to make the point clear, I illustrate by vessels trading during the present war between, say, Bolivia and Peru, the freedom of the sea has a limitation imposed upon it by war, in what is known as the "right of search." The right of a belligerent, by his lawfully commissioned cruisers, to search neutral ships upon the high sea for cargoes which he is entitled to seize, "whatever be the ships, whatever be the cargoes, whatever be the destinations," is incontestable. And the correlative duty of the neutral ship to submit to be searched is equally incontestable, and may not be resisted. By this specific limitation also, the freedom of the sea is modified by war.

But that is by no means the full extent of the limitations which war imposes on the neutrals. Access to the enemy's ports may be blocked by a belligerent fleet, and neutral ships caught running the blockade are seized as prize. Breach of blockade is committed by running in or running out; the breach begins when the ship sets sail upon her voyage with intent, though the port be 3,000 miles away; and the breach outwards continues till the ship has completed her voyage, though her home port also be 3,000 miles away. So, neutral ships carrying contraband of war to the enemy may be stopped at any point of their voyage, taken to the nearest port of the belligerent, their cargoes overhauled, the contraband confiscated as prize of war, and the ship, except in certain circumstances, only then allowed to proceed on her voyage.

It is commonly said that international law sanctions blockade and seizure of contraband. Does it not strike you that the more accurate description is that they are interferences with neutral trade with the enemy, which would otherwise help him win the war? In the old Prize Court decisions you will find abundant references to "prohibitions" by the belligerent to the neutrals, and the language of the criminal law is turned on to the neutral merchant who "infringes" them. Terms of "law" are out of place, and the sooner they are abandoned the clearer will the subject become. The "offence" consists in getting caught. The neutral merchant knows the risk ahead of him when he sets out on his voyage, and he deliberately runs it. If he can get through to port so much the better for his banker's balance; and so much the better for the enemy who gets the cargoes he is in need of. There is no "law" dealing with the question which has any analogy in any other known legal system. It is just "catch as catch can," and that is all there is in it.

This is the interference with the freedom of the sea of which neutral and enemy so bitterly complain. But is it not justified? The neutral merchant is *assisting* the enemy; and if there is any clear "right" resulting from war it must surely be this, to prevent persons who have no interest in the war from giving such assistance. It is a right which both belligerents equally possess, though it is quite true that both may not be able to exercise it with like effect; but that raises the question of supremacy at sea, and to abate this clear belligerent right of war is by so much to diminish the effect of that supremacy.

Just as enemy property is, and may be, seized the wide seas over, so also may cargoes which are going to the enemy in the circumstances known as running the blockade or carrying contraband. These two principles of seizure stand precisely on the same footing—property of the enemy, because it is the enemy's; cargoes going to the enemy, because they are, or will in due course become, his property.

But, you may well ask, why should this clear right of the belligerent be limited, as is so confidently asserted, to blockade and contraband? Assistance to the enemy may, as we know too well, take many other forms. Surely the remedy must be commensurate with the disease! The question which your intuition has propounded is the question round which all the trouble with the neutrals has turned since wars began to be fought upon the sea, and still turns.

The neutral merchant, for all his so-called "innocence," is an exceedingly ingenious person —all persons are where financial profit is concerned—and he has spent, and still spends, infinite pains in devising methods for evading the belligerent's interference with his trade, and inventing reasons why this right of war should not be extended to cover his new tricks. The right depends on a very elastic principle; he seeks to make it rigid, boldly contending that all trade with the enemy which does not fall within those two categories, breach of blockade and contraband, is legitimate. I need not say that the enemy backs him up; and between them they have elaborated all sorts of curious theories, which have very successfully clouded the issue. To these theories I must invite your very particular attention, because they are in certain quarters as rampant to-day as they were a century ago. You will find that, however ingeniously they are varied, always the same question lies at the bottom of them—protection of enemy property; always the same question ignored—the effect on the belligerent.

The foremost of these theories is that "neutral trade is free," which nobody has ever denied. But, they say, it follows from this that neutral trade with the enemy is free, excepting always trade in contraband, and trade with a blockaded port. The fallacy is that these two cases are assumed to be arbitrary exceptions to a pre-existing right of trade in which the neutrals are compelled by a belligerent's cruisers to acquiesce. Some have imagined a theory of compromise, which presupposes equal rights in the parties to it. But "trade" is two-sided. It takes two parties to make a contract of sale. "Neutral trade" means what it says, neutral trade with neutral. When the trade is with the enemy it becomes "neutral-enemy trade," very different in spirit and in fact. To assert that that trade is "free" is to assume either that trading with the enemy, so long as it is not in munitions of war, is of no benefit to him, or that, if it does benefit him, the belligerent must put up with it because of the neutral's profit. What is this benefit? It enables the enemy to sell his produce, creates for him credit, which is his principal munition of war; with credit he can buy contraband goods from his continental neighbours, which not even the greatest fleet can intercept; above all, it enables him to purchase everything he needs to keep his troops fit, and his people in good spirits. To trade with the enemy is therefore to assist the enemy just in regard to those matters in which he most needs assistance. The assertion that the belligerent may not prevent that assistance when it comes by way of the sea is no more than an attempt to deprive him of that force with which a maritime State is endowed by its position—"sea-power." Its object is to render supremacy at sea of no avail.

But all history is against the contention. By "history" I mean the record of how nations have fought in the past upon the sea. "The maritime nations," as Mahan well points out, "are the wealthy nations"; and when they fight it is inevitable that each should seek to destroy not only the other's man-power, but also his wealth-power, for wealth is the sinews of war. In the great war which began in 1793, France and England were like two infuriated dogs—I am quoting Mahan again—who had "locked jaws over commerce, as the decisive element in the conflict." Had they not done so, the war would never have ended. Supremacy at sea is the great factor in victory. Anything that tends to limit its exercise is a weapon in the hands of the enemy, and that is precisely what all these doctrines of the neutrals aim at.

Now there are on record two special forms of attack on this neutral-enemy trade to which England has resorted in her wars, which have greatly helped to bring her victory, and against which neutral and enemy have loudly protested.

In the old days trade with the overseas Colonies was a monopoly of the Mother Country. But when during war the neutrals were allowed to participate in it, their vessels were seized as the enemy's vessels were, because by throwing open his monopoly the enemy sought

shelter behind the neutral flag. And so with his coasting trade, also a time-old monopoly. He sought refuge from the attacks of the English cruisers by allowing the neutral to carry it on on his behalf. In both cases we swept aside the fiction and addressed ourselves to the reality. If the neutral vessels were chartered by the enemy they were identified with the enemy; if they were engaging in the trade on their own behalf, or as carriers, they were giving the enemy the most direct and effectual help short of actual military assistance in the war. What right had a neutral shipowner to do this with impunity? It could not be undertaken, so said Sir William Scott, "without the hazard of rendering himself liable to be considered as giving immediate aid and adherence" to the enemy. It was, of course, assistance in its crudest form, and as such, from the time of the Seven Years War, England declined to recognise it as anything more than another form of the risk which neutrals chose to run for the sake of profit. Hence it has come to be known as the "Rule of 1756."

This, then, must be clear to you—that England's action was *not* an interference with the freedom of the sea; it *was* an interference with the purpose to which the neutral endeavoured to put that freedom, a purpose for which it was never intended — assisting the enemy; and England resolutely refused to admit that he did it as of right. "His Majesty," said Sir Joseph Yorke long ago, in answer to the complainings of the Dutch, "could not otherwise get out of the war with safety." To call this an attack on "neutral trade" is to misrepresent its fundamental characteristics It was action in self-defence, and justified by every known principle which guides human action, and of which all systems of law approve.

But the theory of the complete "freedom of neutral trade" was poor in conception compared with the vigorous assertion that "free ships make free goods." Knowing whence it emanated, there is something sublimely impertinent in the assertion of a neutral shipowner that he has a "right" to carry enemy goods free, always excepting, of course, contraband of war. The neutrals made no bones about what they meant: that the neutral flag imparted, as a natural right, its inviolability to the enemy's goods; that the neutral ship was a sanctuary wherein those goods might escape capture. Why, I wonder! I have never come across a satisfactory explanation of the ethics of the maxim, though there is much vague talk about the benefit of commerce to the world, and the necessity of preserving it harmless in time of war. Its motives are the reverse of altruistic. Historically it was a maxim devised by the sea-carriers in their own interests, and was always advocated by the carrier nations, the Dutch, and the United States when, in the earliest days of its existence, it decided to develop a mercantile marine which should rival, if not outstrip, that of the old Mother Country.

I would have you realise this fact at once—I will abundantly make it good—that at the bottom of all the doctrines which profess to protect the so-called "rights" of the neutral merchant lies no morality, nothing but self-interest. Here, then, on the threshold of the subject is a maxim which rests on fine words only, and fine words cannot entitle it to rank as a principle of the Law of Nations. But I hear, as it were the still small voice of conscience, "Is it not past praying for, since we accepted it in the Declaration of Paris?" I have not forgotten, and before I have done I will tell you something of the lamentable history of that dangerous document. For the moment I can only give you the briefest insight into it. Here are the words: "The neutral flag covers enemy goods except contraband of war." One would have thought that when the plenipotentiaries of the great maritime Powers were settling, as they believed they were settling, a new great principle of international law—one would have thought that when those who represented England, Lord Clarendon and Lord Cowley, were selling England's birthright for a mess of pottage—they would have been careful, to say the least, to use words that should accurately convey their meaning. But even with regard to principles of belligerency which have never been disputed, this statement is untrue; it omitted to record two other exceptions, blockade and embargo, in which the neutral flag does *not* cover enemy goods.

But I will very freely admit that as a carrier *privilege* it might be granted to a carrier nation by treaty, even by a fighting nation, in return for some great and equivalent benefit. It is a fact that in several of the early treaties which England made with Continental nations she did concede the privilege, especially to the Dutch. De Witt spent many years trying to induce England to consent, as other nations had consented. The prosperity of Holland depended on the development of its carrying trade. It was his duty as a statesman to develop it by all means in his power; and he could best develop it by

securing for it those vast benefits which would thus accrue to the free carrier when other nations go to war. But he never supported his diplomacy by assertions that this was a "right" inherent in neutrality; he bought the privilege at the price England demanded for it—alliance. "It was," Pitt declared, "ceded as a matter of favour, not given up as a matter of right."

And so it will be found in all the cases when, at the Peace Conference, this precious maxim, and so many others of its kin, go into the melting-pot, when the dusty despatches are opened and the Public Record Office gives up its dead facts. It has only lately come to the light of remembrance that when Fox went to the Foreign Office in 1782, his first act was to propose to Catherine the acceptance of this principle by England in return for an alliance with Russia, of which we then stood in great need. Pitt, in after years, challenged him with abandoning the old English principle of belligerency. Fox replied: "When I offered it to Russia I meant to give nothing without getting a full equivalent. . . . I was tendering [it] as an inducement to a great and beneficial alliance." But of the maxim he said, "as an axiom, it is supported neither by the law of nations nor of common sense." Yet, in spite of this, there are those who contend that because we have agreed to it in some treaties therefore we have admitted it to be a principle of the Law of Nations. Why, they do not know this elementary fact, that even in the Continental treaties, in which it figures largely, it appears in two forms of very widely different meaning. In one, the most common, it is an agreement that if either of the contracting parties be at war with a third State the other may carry on its trade with that State unmolested; may even carry its cargoes. The other is quite different, and very rarely found, for, I think, obvious reasons: "If the two contracting parties are at war with each other (which God forbid) then the goods of each may be carried on neutral vessels without let or hindrance from the other." In the first form the right of free carriage of enemy goods is granted to one neutral only; in the second, free carriage by *all* neutrals is conceded to the potential enemy; and when people talk about it being a privilege granted to the neutral with which the enemy has no concern, at least we have a right to say to them, "Verify your references."

Time will not allow me to pursue this important point. I must press on to dwell, all fallacies apart, on the insidious danger of this maxim. From being at its inception a carrier maxim—bad enough, that neutral carriers had a right to protect enemy property—it gradually developed into a vendor and purchaser's maxim, protecting the enemy's purchases from the neutral vendor. So this came about: that goods sold to the enemy, where the property remained in the vendor, could not be seized because they were neutral property; and if the property had passed to the enemy and was conveyed in neutral ships, then also it could not be seized.

If this maxim is a principle of the true Law of Nations then all the principles of belligerency which England has relied on in her wars, on which her supremacy rests, go by the board. This is the foundation of the "freedom of the sea" for which the enemies of England, in conjunction with the neutrals, struggled. Can you be surprised that Pitt declared he would resist it "to the last shilling and the last drop of blood?" This was not mere war-rhetoric. It was Pitt's deliberate estimate of the value of this principle in helping the enemy to carry out his design. What that design was is written in M. de Vergennes's "*considérations*" why France should assist the revolted colonies of America:—"Providence had evidently chosen that very hour for humiliating England and revenging on her the wrongs she had inflicted"; it "would afford an opportunity to reduce England to the condition of a second-class Power."

Wrongs! wrongs! Always this cry of wrongs committed by England on the sea. Here is what an American historian, Fiske, says: "During the autumn of 1778 and 1779, Prussian, Swedish, Danish, and Dutch ships were continually overhauled by British cruisers, and robbed of cargoes which they were carrying to France." Was there ever so flagrant *petitio principii*? Those seizures could only be "robbery" if the maxim had anything of international morality in it. If it had none then they were no more than the exercise of a legitimate act of belligerency.

I have brought you now to the stormy period of the American War of Independence, when these questions were so vehemently discussed But I crave your patience one moment longer while I deal with that admitted curtailment of the freedom of the sea in right of war which I have already mentioned, the "right of search." This right is so broadly stated that it inevitably gives rise to protests which have all the appearance of being legitimate. But, suppose a vessel searched and contraband going to the enemy found on board, which the belligerent has a

right to seize. The search was then justified, for how else was he to seize? If the cruiser was mistaken, then the search was not justified, and compensation must be paid. But compensation may not be considered sufficient to atone for this "insult" to the neutral flag. It would seem then to be a case of the innocent suffering with the guilty. But now look at the other side of the question. The denial of the right of search carries with it the claim to give sanctuary; and, even in the case of contraband, which cannot be seized without search, it involves the interposition of the neutral flag between the belligerents. These are the two stools of logic, and in spite of the hardship, the propensity of the neutral merchant being what it is, the right of search, even in its largest statement, must be accepted as the inevitable consequence of war. But in practice it is obviously controlled by checks and balances, of which discretion is the chief. No belligerent has either the ships or the time necessary to send cruisers roaming over the sea on a speculative hunt for contraband. Quite apart from the fact that no belligerent wants to pay enormous sums in compensation, search is governed by what are called "sources of information," and the right is in fact only exercised when there is reasonable suspicion that the cargo on board is seizable.

This, then, was the point in dispute between England and the neutrals from 1756 to 1815. The neutrals declared that their flag was immune upon the sea; England declared that it was not immune when it was used to cover assistance to the enemy. If England was wrong, what she did was in fact an "insult" to the neutral flag. But this cry of "insult" was the merest *camouflage* for the claim of the neutral to a *right* to carry enemy property, other than contraband, free. Unless this right could be substantiated, all the declamation about "robbery on the high seas" was jargon.

You shall judge for yourselves. Here are the facts of a "little activity" in the Channel at the end of 1779, by which time France had openly espoused the cause of the American colonists. A fleet of Dutch vessels came sailing through the Downs under convoy of five warships. There happened—blessed word so expressive of the Navy's ubiquity—to be a British squadron of seventeen ships-of-the-line standing across their course. Search of the convoy was demanded, and refused; there followed an exchange of broadsides, and, honour being satisfied, the Dutch flag was hauled down. Some of the convoy got away to the French port; but some being seized, their cargoes were discovered to be ship's timber and naval stores for the enemy. "Discovered" is another blessed word of many meanings. In this case we knew all about the loading of these vessels in the Texel, and had made vigorous diplomatic protests. These facts are sometimes omitted in the narrative, which dwells only on the "robbery" and "outrage" and "insult to the flag."

I should tell you that the Dutch maintained that they had a right to send these cargoes under the Treaty of 1674. For those who care to follow out that point, I commend to their attention Sir James Marriott's judgment in the case of the "Vryheid." He interpreted the Treaty, and held that it was not its intention that the Dutch "should become the transports of the enemy's Government for carrying free its stores either by sea or land."

But the French dockyards were in the greatest need of masts, and timber, and stores, for repairing their ships and building new ones. Without ships England could never be "humbled." If, then, the neutrals had a right to send these cargoes free, the enemy had a right to receive them free. It is seriously contended that England was bound to stand by and let these "transports of the enemy" pass down the Channel. This is the "freedom of the sea" which was claimed in war! It is not the true freedom of the sea. There was no such duty imposed on England. It was in right of war that she seized those cargoes; nay more, it was her bounden duty to her own people to seize them; she acted in self-defence, a right on the exercise of which the safety of the State depends.

But the neutrals were far too ingenious to be satisfied with a simple issue. They proceeded to complicate it by asserting that ship's timber and naval stores were not contraband of war! The theory of international law has this very grave defect: it does not define the terms it uses. Dispute as to its application therefore becomes inevitable. "Contraband" means things useful in war, obviously a very elastic term. Yet the neutrals gravely asserted that timber for building warships, masts, iron, hemp, and other stores, were not contraband. Can you be surprised that England declared that she would not accept the contention, and acted accordingly? It is true that the neutrals had no sinister design against England. They professed friendship for her; but this friendship was not to deprive them of the profit resulting from free delivery of cargoes

sold to the enemy; and for this they nearly came to quarrelling. I will carry conviction to your minds by quoting extracts from two despatches, which will give you the key to the situation. Sir Thomas Wroughton, our Minister in Stockholm, wrote in February, 1780:—"I am constantly assured that we give too great an extent to the appellation of naval stores, which being the natural and sole production of this country, such an impediment to their exportation cannot fail of being a great detriment to its trade and revenues."

And from Copenhagen, our Minister, Mr Morton Eden, wrote about the same time, in regard to the victualling trade:—"It was a point the Danes could never give up, nor would: it was the only production of the country, and the loss of this branch of commerce must be highly detrimental."

Hostile critics would have you believe that we flouted the neutrals demand, and continued to confiscate their cargoes. England is not absolutely blind to her own interests. She does not willingly offend the neutrals, except when they give her cause, for the simple reason that she must protect her own trade with them. She recognised the injury which *confiscation* of cargoes of neutral produce must inevitably cause these countries; and where there were no aggravating circumstances, she substituted *pre-emption*; in other words, she bought the seized cargoes herself, and paid for them. This satisfied her claim as a belligerent to prevent the enemy getting them, and should have satisfied the neutrals. To reject this, and still persist that the cargoes must go forward to the enemy, carries me a long way in my argument, that assistance to the enemy is at the root of all the trouble.

I have set the facts before you simply, and I hope fairly, in order that you should appreciate on what flimsy foundation the assertion rests, constantly made at the time of her great wars, and, of course, renewed to-day, that England is and always has been the "Tyrant of the seas"; and specially because it is these acts which statesmen like Lord Clarendon described as "acts of barbarism" when they forced the Declaration of Paris on the nation; and because it is on the same foundations that the German "Freedom of the Sea" rests. Also because it is essential that you should know the real facts about the two Leagues of Neutrals which were formed against England in 1780 and 1800, known as the Armed Neutralities. It is surprising how little you will find in the history books about them; astonishing that a large percentage of what you do find is wrong, and gives you an entirely false impression. The critics of our sea-policy point to the results of these two Leagues in witness of its perversity. Mr. Fiske, the American historian already mentioned, declares that the first brought about "one of the greatest and most beneficent revolutions in the whole history of human warfare"; and, I grieve to say, an English politician, Sir William Molesworth, in a debate during the Russian War, declared that the Armed Neutralities had achieved their object! It is all stuff and nonsense.

I have written the story of these Leagues at length elsewhere, but it will bear repeating. It is a true story, because it is drawn from despatches written at the time. The clock warns me that time is on the wing; but I crave your patience still further while I tell it to you as succinctly as possible.

In 1776, owing to the surpassing folly of the British Government, the thirteen American Colonies revolted, and there burst upon us the storm which had long been brewing, the War of Independence. The infuriated Americans sent Commissioners to every European State to gather ways and means for carrying on the war, and to stir up hostility against their oppressor. We may talk of these things now as they really were with perfect frankness, for they are history. Their avowed object was not merely to obtain recognition as a State, but to compass the humiliation of England. In two countries they were eminently successful, France and Spain; France, still smarting under the effects of the Seven Years' War; Spain, with another very old score to wipe off, the loss of her supremacy at sea. Louis XVI. hesitated; it seemed to him inconsistent with his dignity to ally himself openly with colonists in revolt, though not so to show his sympathy with them in secret. For two years he tried to keep up a show of friendship with England while sending supplies across the Atlantic, receiving in exchange what the Americans had to sell, especially tobacco, some of which, it may please you to know, went to fill the pipes of British sailors. But in 1778, yielding to the arguments of M. de Vergennes, he declared war, and Spain followed suit. Thus the war spread to Europe. To the neutral timber merchants and ships' chandlers an immense business was opened up; and the phlegmatic Dutchmen looked forward to great profits as carriers. Then occurred incidents in

the Channel such as the one of which I have told you—Mr. Fiske's "sea-robberies" of cargoes going to France; and the Scandinavian Powers sought counsel of Catherine of Russia, that strange woman whose ambition it was to sway the destinies of Europe.

The position of England was full of danger, standing alone in the world with war in both continents on her hands; so full of danger that the only way through seemed to lie in an alliance with Russia. Sir James Harris, afterwards first Earl of Malmesbury, was entrusted with the negotiations. Louis, for reasons of his own, sought to appease the neutrals, and abandoned the old policy of seizing enemy goods on neutral ships; but Spain adhered to the practice in maintaining the siege of Gibraltar; and Paul Jones, for the colonists, did what he could with the "Bonhomme Richard," raiding the Firth of Forth and the Humber and seizing cargoes. Catherine was watching and waiting. At times she raised Sir James Harris's hopes that she would consent to the alliance; at times her waywardness filled him with despair. Suddenly, the ostensible reason being the seizure by Spain of a neutral ship going through the Straits of Gibraltar, she sprang upon our bewildered Ambassador a Declaration, directed to the belligerents, which the neutrals, long prepared for it, were invited to join. This was the prelude to the First Armed Neutrality of 1780.

Very naively she set out with the statement that "all hope that her subjects would have peaceably enjoyed the fruits of their industry, and the advantages belonging to a neutral nation, had been unfulfilled." In order to secure them she proclaimed her intention of insisting on four principles, asserting that they were based on the primitive Law of Nations, one of which was that "goods belonging to nations at war, except contraband, shall be free in all neutral ships." To maintain these principles and protect the honour of her flag, a considerable portion of her fleet had been put into commission, "to go wherever honour, interest, or necessity compelled." She promised herself that her wishes would be accomplished by the assent of the belligerents to her proposals, and pointed to the proofs of the "sentiments of justice, equity, and moderation with which she was animated," which she had given in her war against Turkey. This, I regret to say, was denied by an honest admiral of her fleet, who declared that Turkish property had been invariably seized on board neutral vessels.

The English answer published in the books is a most unsatisfactory document. Sir James Harris himself afterwards described it as "ambiguous and trimming." The *real* answer which he was instructed to present to the Empress, and did in fact present, gave no uncertain sound. Lord Stormont wrote, "We cannot and will not subscribe to such doctrine, I have repeatedly told you."

For some reason which I cannot pretend to understand, Lord Stormont's instructions are omitted from the well-known "Malmesbury Correspondence," and had passed out of mind until they were unearthed a few months ago in the Public Record Office. I lay stress upon this now because undoubtedly the publication of the mutilated despatch in a book which has passed for many years as accepted history, has influenced opinion against us in foreign countries, especially in the United States; perhaps also in our own. It is well, therefore, that this should be publicly stated; that never, in spite of armed coalitions arrayed against us, in spite of all the denunciations levelled against us during the Napoleonic Wars, never did England, between 1756 and 1815, waver one hair's breadth from the practice of seizing enemy goods on neutral ships, which she held to be warranted by the Law of Nations. Lord Stormont's despatch proves this as to 1780; Pitt's speech proves it as to 1800; and a despatch of Lord Castlereagh, also recently unearthed, proves it for 1815. *He declined to allow the question to be discussed* at the Peace Conference; and it was not discussed.

Catherine succeeded, however, in getting a formidable number of nations on her side. Denmark and Sweden adhered at once; the United Provinces in 1781; Prussia and the Emperor of the Romans in the same year; Portugal in 1782; and the Two Sicilies in 1783. Mutual treaties were concluded in which her precious principles were embodied. She was declared to have won the applause of all Europe. Applause was incense to her nostrils; but it is sometimes organised from the prompter's box, and those who applaud are known as the *claque*.

But in spite of the troubles, and this array of the neutral nations, England did stand firm. The neutral squadrons did nothing; I doubt if their batteries were really intended to be of any more effect than the painted muzzles on the gates of Peking. The first Armed Neutrality became, as in a moment of confidence Catherine had herself prophesied, an "Armed Nullity."

Peace was signed in 1783; the "United

Colonies" became the United States of America; the echoes of the war were lost in promises to forgive and forget; the profits of war-trading vanished; the subject of neutral rights ceased to interest, and Catherine's draft code of Maritime Law, intended to create the new "Freedom of the Sea," went to its appointed place, the pigeon-hole. Peace reigned in all the world—for ten years. Then began the long struggle which lasted from 1793 to 1815, and the old dispute broke out again—what was the measure of assistance which neutral merchants might give to the enemy? Only, strange to say, Catherine now allied herself with England, and was vehement in her denunciations of the "six hundred monsters" who had slain the Lord's Anointed.

But the ingenuity of the other neutrals was not yet exhausted. Remembering how roughly the Dutch convoy had been handled in 1779, they proposed to invest their flag with a new sanctity; and hoping thus to put an end to the "right of search," turned their attention to another variation of the same claim, the "right of convoy." By this they meant that the belligerent—England—was to accept the statement of the commander of the escort that there was no contraband on board his convoy, and the ships were to be allowed to pass on—to the French ports.

Now if there had been an agreement as to what was contraband of war, it is quite conceivable that the English captains would have been told to accept the word of a naval officer. The neutrals were quite honest according to their lights, and endeavoured to prevent what *they* called contraband from being loaded on their merchantmen. But the old question of ship's timber and naval stores was still open. The neutrals still sold them and sent them to France—*down Channel!*—and persisted in claiming their freedom from capture. Down Channel! Really, reading the correspondence of that time one can hardly be surprised at the old claim to the Narrow Seas. The struggle on the sea had reached a pitch of great intensity; the French dockyards were working at fever-pitch repairing and building ships. The neutrals contended that they had a *right* to send to the enemy the supplies for ship-building he so sorely wanted, within sight of the cliffs of Dover. Surely Providence was never so tempted!

I beg you most earnestly, in these days when the old strife has been renewed, to appreciate the true position. It is so simple. There was no "law" prohibiting the neutrals from selling and sending their naval stores to France; nor was there any "law" prohibiting England from seizing the cargoes. It was just a risk which the neutrals ran with their eyes open, the risk that their cargoes would be seized. They ran the same risk at the hands of the enemy, if they chose to send their ship's timber to England. To turn this risk into an unchallengeable "right" is the "Freedom of the Sea" which the neutrals claimed then, it is the "Freedom of the Sea" which Germany claims to-day. How can you expect, now that all theories have been subjected to the rough test of war, that England can possibly accept it! But the theorists are again abroad, the old fallacies are being aired once more.

Well, the convoys were as roughly handled in 1799 as they had been in 1779. Catherine was dead; but Paul, her son, had ambitions of his own, broke away from the alliance with England which his mother had made, listened to the complaints of the Scandinavian Powers, and launched a new Declaration, in which there were the same old appeals to the primitive rights of nations, and to the applause of all Europe. The same four principles were laid down, with the "right of convoy" added, and England's acquiescence in them demanded, and of course refused. This, in briefest outline, is the story of the Second Armed Neutrality.

But there had arisen in the world a new force which for many years was to dominate it, was to concentrate in itself all human ambition and become the incarnation of power; a man who, sweeping aside the unstable Government of the French Revolution, absorbing the weak States of Europe, aspired to lay low that presumptuous little island, England, and wrest from her the supremacy of the seas—the man who, at the time of these happenings, was First Consul of France, Bonaparte. By a curious irony he has become as great a hero in England as in France. Adulation has been poured out in great libations at his feet. I am not going to dispute his claim to unrivalled military genius; but I sometimes wonder whether his correspondence at this period has been sufficiently studied. It does not bear the impress of a great mind. Nothing was too mean, too paltry, if it served his ends. He truckled to Paul, whom he clearly despised; fooled him to the top of his bent. So curiously did his brain work that he conceived that he, a belligerent, might be admitted to the League of Neutrals, and was coldly rejected. They were willing to sell ship's timber to him: with that he

must be content. But the safety of the cargoes was of greater importance to him than to them, and insistence on "free ships, free goods" was imperative. I must emphasise this, because the theorists refuse to recognise that this maxim is more beneficial to the enemy even than to the neutral; and not the theorists only, but statesmen whose knowledge of these grave matters is sometimes surprisingly shallow.

But Bonaparte was too astute not to appreciate the weakness of the neutral argument; must have been conscious that, with the question of what was contraband still unsettled, the claim of immunity for the neutral flag was much in need of strengthening. Two new theories were therefore launched upon the world. The seeds had already been sown in the earlier controversies, and had received some cultivation from writers of books; but their gradual development by Bonaparte may be distinctly traced till they took definite shape in the preamble of the Berlin Decree, and their recognition laid down as a condition of peace. These theories were: first, that war on the sea must be waged according to the same principles as war on land; secondly, that private property at sea must be immune from capture during war. Though they were presented as two independent propositions, they really meant precisely the same thing; were no more than a very clever new way of putting that old crude doctrine of the neutrals about the rights of their "free ships," dressing it up in new garments which appealed to the philosophers of the time.

It certainly is a tribute to Bonaparte's cleverness, that though England would have nothing to say to them, though Pitt denounced them, though Castlereagh declined to discuss them at the peace, they lived and flourished forty years after, when humanitarianism, commercialism, pacificism had gotten hold of the minds of many politicians. They became the pet theories of the Manchester School, and of the Philosophical Radicals, and also of the remnant of a great political party, the Whigs. Alas! they are alive still, finding some support even in England. I would have you beware of them, for they form the basis of the German "Freedom of the Sea."

My allotted time is already far spent, and I must content myself with two brief remarks, which I hope will show you the fallacies involved in these doctrines.

First, the fallacies have been ruthlessly exposed by the great American historian of the sea, Admiral Mahan, so lately as in his study of the "War of 1812," published in 1906. He points out that private property *is* always free from capture, and that to take it either on sea or land is just common theft, which war does not allow. But when private property is set in motion across the sea it becomes "commerce," and is merged in the national property. If it be commodities, it is part of the national wealth of the enemy; if it be ships, they serve to carry that wealth to the markets of the world, to carry munitions of war and troops, and if they were immune from capture the enemy's fleet would be freed from the duty of protecting commerce from attack, and could devote themselves entirely to fighting. "These words," Mahan adds, referring to the Berlin Decree, "struck directly at measures of war resting upon long-standing usage, in which the strength of a maritime State such as Great Britain was vitally implicated."

But secondly: the sophistry of these theories got the better of men's intellects during the Russian War, and were swallowed wholesale when the Declaration of Paris, which accepted the neutral maxim, was forced upon a blindfolded nation; as to which one word only. At the outbreak of the war our alliance with France necessitated an assimilation of maritime practice. We accepted the maxim "free ships, free goods," as the nation was assured in Parliament, for the duration of the war only. Yet when the war was over, it was accepted permanently, in contempt of this assurance, at the Congress of Paris. No warning word was uttered; it was a bolt from a clear sky. No despatches were ever published, in which the rhyme or the reason of it might have been discovered. A few speeches from pedants of the Milk-and-water School are all we have from which to glean some excuse for this radical alteration in our methods of waging war at sea. But we now know the reason for all the secrecy and the silence. Lord Clarendon and Lord Cowley privately informed the French Government that they *dared* not make the change publicly "in the face of the people." For why? They knew full well that the people, as distinct from the politicians, would never have accepted it. I am sure that it will be sufficient for me to say this: that all the talk you now hear about these two theories is nothing but a revival of the old Bonaparte doctrines. As Englishmen you will decline to accept them, because they were the most insidious of the weapons which he devised for the undoing of England.

But if they are to be made the basis of the

League of Nations, which men now talk of as the panacea for all the troubles of war, it is, for that same cause, which I hold to be very sufficient, doomed to failure. Believe me, their acceptance is all that is needed to ensure the "Freedom of the Sea" which Germany is planning to achieve to-day, and will be the prelude to the successful accomplishment of her dream, the domination of the world.

I speak now in no spirit of vain-glorious boasting of my faith in my country. If "England" means anything to-day, as I believe she does, it is because she has created the true Freedom of the Sea, and in peace has opened wide her ports to the merchant commerce of the world; it is because she has declined to allow a spurious freedom to be substituted for it in time of war; it is because when she has gone forth to war she has known what war means, and has held to the only principle on which war can be successfully waged—to be strong enough, when the stress of war compels her, to put forth all her power upon the sea, to prevent neutral assistance in any form from reaching the enemy. To that end Pitt laid down his great principles of belligerency, which denied all the doctrines of the Armed Neutralities, all the sophistries with which Bonaparte endeavoured to support them.

And if "England" means anything to-day, as I know she does, not to herself alone, but to the Allies, it will be for them, when the time comes for declaring the true law of the sea, to bring to the discussion an open mind, to discard all pre-conceived notions and theories, to abandon those pernicious things, maxims, and go back to principles, and by the light of cold reason to review the facts of the story of sea-warfare, which is the history of England. They will then—I speak with unbounded confidence—they will then at last agree that England's position has been fairly and rightly won, has been loyally held, not in her own interests alone, but as a great trust, in the interests of the world at large, and that every act of her belligerency has been compelled by the safety of the State, and warranted by the stern justice of war.

Not the dreamiest of pacifists but admits that his pet League of Nations must, if a swift malignant stroke should come from the rebellious State before the slow-moving economic boycott could be got to work, resort to force. Force is to be the ultimate sanction of the League, as it is of all mandatory bodies. Force means war, and the ultimate battle must be fought upon the sea. Therefore the League must hold the command of the sea; and supremacy at sea can only be maintained by those principles which have enabled England to achieve and maintain it. England is asked to share that supremacy with the other nations of the League, to bring her heritage into "hotchpot." She must see to it that those principles are maintained. There must be no carrying of *this* enemy's goods free under the shelter of a friendly neutral flag. There must be no immunity for *this* enemy's property from capture at sea. All the imagined benefits of commercial brotherhood will be as Dead-Sea fruit if *this* enemy defeats the League. There is no middle course. The League must win the last great battle, or *this* enemy will win it. And in the principles of English maritime warfare lies the only way of safety for the free nations of the world.

FORESTRY IN CHINA.

Writing in the *Indian Forester*, Mr. F. Sherfesee adviser in forestry in China, gives an interesting account of what has been done and what is intended towards the establishment in China of a forest service under the Ministry of Agriculture and Commerce. He states that China has suffered, and must continue to suffer, owing to the wholesale deforestation which took place centuries ago, and that it was not until the establishment of the Republic that the importance of forestry was recognised. To Mr. Chow-Tzuchi, recently Minister of Agriculture and Commerce, must be given the credit for the inauguration of a nation forest service so recently as 1916. Among others, an English expert, trained at Kew, namely, Mr. William Purdom, serves as the chief of one of the six divisions into which the service has been organised. The general policy laid down is as follows: To lessen the present scarcity and high price of timber fuel and other forest products by the afforestation of public lands unfit for agriculture and practically waste. To regulate stream-flow by the planting of river sheds and catchment areas. To protect and manage on forest lines such public forest resources as still exist. To encourage private owners to plant by supplying advice and practical assistance. To conduct a vigorous pro-forestry propaganda throughout China, showing to all classes of people the need of forestry, what it means to the country, how it affects health and prosperity. To train young men to become foresters, and what are called inspecting forest nurserymen, whose duties will be chiefly the supervision of the initial work of forestry. It is also intended to instruct and interest school teachers in the principles and importance of forestry in order that they may impress upon the general student-body what it means to the country, and what the State is doing to foster it.

PRODUCTION OF MENTHOL IN JAPAN.

About 85 per cent. of the peppermint grown in Japan is raised in Hokkaido, which, together with Okayama and Hiroshima Prefectures, produces practically all of the Japanese crop. In Hokkaido it is cut only once a year, in September. In Okayama and Hiroshima it is cut three times—in July, September, and November.

The preliminary steps in the manufacture of menthol, writes the United States Vice-Consul at Yokohama, are carried out by the farmers themselves, with the aid of stills of a simple design. The peppermint plants are first dried in sheds, or under cover from the sun, for thirty days. Then they are placed in the stills, where they undergo a process of steaming. The resulting vapours are led off through pipes into cooling chambers, are condensed, and deposited as crude peppermint oil. This crude peppermint is shipped to Yokohama and Kobe, where factories are equipped to subject it to a process of fractional distillation to obtain the full content of menthol. The residue of oil is further refined to the standards of purity required in the trade, and is known as peppermint oil.

Before the war about half the menthol crystals exported from Japan were sent to Germany. Since the outbreak of the war the United States has become the largest purchaser of these crystals, followed in order by the United Kingdom, France, and British India.

The price has varied from 8*s.* to 10*s.* per lb. in recent years, remaining most of the time near the higher mark. Improvements in the process of manufacture have kept the price within reasonable limits, in spite of a considerable increase in the demand since the beginning of the war.

The figures for production in Japan are not complete, but are given in the official returns as follows:—

	lb.		lb.
1912 . .	202,124	1914 . .	320,564
1913 . .	260,120	1915 . .	502,181

ENGINEERING NOTES.

Queensland Lighthouses.—Before a meeting of the Liverpool Engineering Society, Mr. Ramsbotham, Director of Lighthouses for the Commonwealth, gave an interesting lecture recently on the above subject. He explained that the towers of the lights consist of four-legged steel structures, subdivided into four bars and braced in the usual way. The height of their platforms is 42 ft. 9 in. above the concrete foundations, the focal plane of the light being nearly 6 ft. higher. The foundations differ for each light. Those at Coquet Island and Clerke Island offered no special features, both being above high water and not subjected to any wave action. At Dhu Reef, where the actual site of the light is 18 in. below h.w.m.s.t., it was determined that at a depth of 9 ft. 6 in. the coral conglomerate, intermixed with sand, was sufficiently dense to stand a load of 2·375 tons per square foot. For the Piper Island light, which is established on a coral reef, it was ultimately decided to drive a nest of five ferro-concrete piles under each pier, excavating and putting a reinforced slab, 19 ft. square and 3 ft. thick, on the top. The necessity of driving the piles to a "sett" was recognised, but none of them could be so driven. In the author's opinion, nothing can be allowed for skin friction for piles driven in coral, and he decided to increase the bearing area to 963 sq. ft., reducing the intensity of stress to 0·725 tons per square foot. Acetylene dissolved in acetone at ten atmospheres pressure is used, and there are ten cylinders, each containing 117 cubic ft., all coupled together. They are changed once a year. The light is turned on and off by a sun-valve, which is so delicate that the light has been seen to come into operation during a rainstorm. A pilot flame is always burning. The lights are of 1,500 candle-power, with a visibility of thirteen miles. So far—*i.e.* since 1913—no trouble has been experienced with any of these unattended lights. The first cost compares favourably with that of a manned light, and the running cost is only £30 against £578.

Ferro-concrete Ships.—These have apparently come to stay. A 5,000-ton vessel of this class was launched a few months ago at San Francisco, and has since undergone an eighty-mile-an-hour gale, with waves thirty feet high, and has behaved herself admirably, with absolutely no vibration. As to other vessels, says the *Daily Telegraph*, reports from the various reinforced-concrete shipyards in England, Scotland, and Ireland, show that good progress is being made in the construction of 1,000-ton sea-going barges for the Admiralty Department of Merchant Shipbuilding. Vessels of this class are urgently required, and the programme of construction already authorised comprises barges and other vessels representing some 200,000 tons of shipping, and a capital outlay estimated at nearly £4,000,000, apart from the cost of land and shipyard plant. On the designs adopted, the saving of steel is fully 70,000 tons on what would have been required for steel ships of the same carrying capacity. It is believed that a still larger saving will be effected when practical data become available as to the minimum proportion of reinforcement that may be employed with safety.

Sea Water and Ferro-concrete.—A question of great interest in connection with this matter was discussed lately before the Faraday Society by Professor Creighton, of Swarthmore College, Pennsylvania. He outlined the process of the corrosion of iron by brine, and pointed out that, in addition, auto-electrolysis may occur owing to the electrical potential differences which exist in commercial forms of iron as the result of the presence of segregated impurities. These differences, which are augmented by chlorides of the alkali metals, bring about galvanic action, which causes the iron

to go into solution at certain points with formation of oxide. Reinforced concrete, therefore, which comes in contact with brine or sea water will begin to deteriorate. As both iron oxide and the hydrated oxide occupy a larger volume than the corresponding amount of iron, there will be developed an enormous expansive force, which is sufficient to crack the strongest concrete and force it away from the reinforcing rods. The more porous the concrete, the more rapidly will this disintegration set in. The durability of reinforced-concrete ships is therefore a matter of considerable doubt, unless the sea water is prevented from coming in contact with the reinforcements. Such prevention may be effected by coating the reinforcements with a protective paint, or by applying to the outer surface of the concrete some material that will render it waterproof. The concrete should undoubtedly be made from cement of fine pulverisation, low in alumina and high in silica, as free as possible from gypsum, absolutely free from lime, slow in setting, and quick in hardening.

Reinforced-concrete Sleepers.—There has been always a well-founded reason against these sleepers, owing to their want of resiliency, notwithstanding their durability. Iron sleepers have been used in India and elsewhere in consequence of the scarcity or unsuitability of timber, but they have been condemned in rock cuttings and in broken stone, as against gravel ballast, where resiliency is noted. There is an article in the *Railway Gazette* of July 19th dealing with the general subject of railway construction as applied to reinforced-concrete sleepers. The article gives two well illustrated examples—the Meyrick and the Yoke patents—of doubled sleepers each on a separate rail, connected by occasional iron tie bars, where the want of resiliency has been counteracted by the interposition of felt and timber packing, these standing several tests. Australia and some parts of North and South America seem, owing to their abundant timber supplies, to be in no need of reinforced-concrete sleepers.

Electric Shunting Locomotive.—The *Railway Gazette* is indebted to Mr. G. Hughes, chief mechanical engineer of the Lancashire and Yorkshire Railway, for particulars of the above, which has been designed and constructed at the company's works at Horwich. The locomotive is of the accumulator type with batteries divided into two parts, so that the two portions can be used in parallel, to give a voltage of 120, or when working in series 240 volts. The control system provides series parallel control on motors at 120 volts or 240 volts. There are ten notches on the controller for both voltages. The 120-volt supply is used for shunting purposes, giving a speed of about 4·5 m.p.h. The 240-volt supply is for running from place to place, the free running being 20 m.p.h. on the level. The tractive force exerted at the rim of the wheel up to 2·3 m.p.h. is 5,400 lb., and at the hourly rating 2,500 lb. at 4 m.p.h. The locomotive was designed to handle three loaded 20-ton coal waggons (90 tons) on an incline of 1 in 180. The engine can be operated by one man, and when the work is not continuous this man can perform other duties, it being left without any attention, but is ready at a moment's notice to perform shunting work. The capacity of the battery will admit of 3·2 hours continual shunting, or a 4 hours' continuous run "light" on the level at an average speed of 20 m.p.h. During the dinner hour a boosting charge will give back to the battery 40 per cent. of its total charge, raising the shunting capacity to 4½ hours. The locomotive is fitted with a vacuum brake and hand brake. The vacuum is produced by means of a small electrically-driven exhauster worked from either half of the battery.

A New System of Goods Transport.—Mr. F. Dutton, superintendent of South African Railways, has written a paper on the above subject, says the *Engineer.* He divides the matter into two parts, a motor tractor and train following, and, secondly, what he calls a loco-tractor. The latter forms a narrow-gauge railway (without a steam locomotive, the power being actuated by petrol through a pair of wheels), with the broad motor wheels behind the petrol motor. The wheels being lifted up, enable a narrow-gauge pair of flanged wheels to act in support of what the writer calls wheel-ways, which are on the outside of the rails. A trial trip has been made with rails of 16 lb. per yard, grades 1 in 20, curves 50 ft. radius; no ballast except that furnished by the wheel-ways; sleepers 1,760 per mile; speed 18 miles per hour; rubber tires on wheel-ways 1,330 lb. per ton, and on rails 344 lb. per ton; weight 5,655 lb. on the driving wheels, and 3,000 lb. on the rails. The estimate per mile was £320 for permanent way, £250 for earthwork, £50 for tracklaying, £150 for wheel-ways, total £770. The trial seems to have been a complete success. The report does not seem to give the gauge of the railway, but it is, without doubt, the South African type of 3 ft. 6 in.

The Maintenance of Electric Locomotives.—Trains of seventy-five ore-laden cars, each averaging at least sixty-eight tons, are not uncommon on the Butte, Anaconda and Pacific Railway, and there are now 262,400 volt direct current locomotives in use—those of the freight type weigh eighty-two tons each—as well as three tractor trucks of about half this weight. The electrical maintenance of all the locomotives and the tractor trucks is undertaken by two electricians and an assistant, who do all the rewinding of armatures and field coils, besides attending to the car heating and lighting equipment, a feat that would hardly be possible on a steam system with so few men. The passenger locomotives are inspected electrically and mechanically every thirty to forty days. In actual practice not more than one hour per unit is required from each electrician at the period of inspection.

Railway Material for Australia.—Experiments conducted by a special investigational committee, appointed by the Chief Railway Commissioner in New South Wales shortly after the outbreak of war, with a view to discovering a method of producing locally manufactured accessories necessary for the construction of railway rolling-stock, have met with almost entire success, says the *Melbourne Age.* The discoveries of the committee comprise a locomotive superheater equal to any that has hitherto been produced in any part of the world; steel railway axles superior to Krupp's; steel railway tires which have demonstrated by actual test satisfactory life; a new type of Australian boiler plate; the utilisation of a substitute for tin; and the invention of a method of building up worn tramway rails and crossings so as to make them again useful, not once, but several times.

The Erith-Riley Automatic Stokers.—For the latest extension of their electricity works, involving boilers with furnaces 15½ ft. wide as before, the Corporation of Hull have placed with Erith's Engineering Co. an order, their fourth, for these stokers. This order is for the high-duty pattern, with one-third greater capacity than the previous ones, and suited for a normal duty of three tons an hour. As a recent sample of the coal allocated to the Corporation contained thirty per cent. of incombustible ash, as compared with eight to ten per cent. in their pre-war coal, the continuous-cleaning feature of the stoker will be called upon to deal with nearly a ton of ash an hour. Erith-Riley stokers, with a normal duty of three tons an hour, are also being delivered to the Bow power-house of the Charing Cross Co. This information is extracted from the *Times Engineering Supplement.*

Coal in Queensland.— The Ipswich deposits, twenty-five miles from Brisbane, occupy 12,000 square miles, and the greater proportion of them are worked in this field, but the most important are the palæozoic coalfield in the Burram, fifteen miles north of Maryborough. The quantity of coal won from the State during 1915 was 1,024,273 tons, valued at £409,342. Further deposits are expected to be developed, according to the *Engineer.*

The Captured Gun "Bertha."—This gun was employed in firing lately on Amiens. The tube, 26 ft. 3 in. in length, is mounted on a chassis quite twice its own length. The 11-in. gun points its 26 ft. nose skywards from the centre, and the rear part is covered by an iron awning, under which is the conducting trolley for the shells, which are stored in a truck immediately behind. Coupled to this waggon are three more, the first containing cartridges, and the remaining two being reserved as living quarters for the gun team. A technical expert present said that the gun was only good for 200 rounds. Fourteen men, according to the *Times*, are necessary to control her fire, and fifty men in all for every purpose. The shell weighs 620 lb.

GENERAL NOTES.

Paper Supplies.—It appears from a statement made at the offices of the Paper Controller that an addition of 10 per cent. has now been made to the country's paper supplies by the use not only of waste paper, but of home-grown timber, straw, and reeds, in the making of pulp. It is hoped that in time improved methods of making paper from native materials may be devised. So far they have not proved the most economical form of production.

Germany's War "Substitutes."—A writer in the *Frankfurter Zeitung*, discussing the question of transition economy in Germany, says: "Of the pre-war imports, of which the value was 10 milliards of marks, 5 milliards were raw materials and 3 milliards foodstuffs and tobacco. Some of these we have done without during the four years of war, while for some substitutes have been found. Many sacrifices have been made. In the cotton trade, of 1,700 spinning and weaving factories, only 70 large ones are working; in the silk trade, of 45,000 looms, only 2,500 are at work; in the oil industry, only 15 out of 720 businesses are still active, while in the boot and shoe trade half the firms are closed. And after the war, when millions cease from war work, much raw material will be required. . . . Many war substitutes will continue to be used after the war." In a statement issued by the Imperial Department of Economics it is claimed that the post-war position will not be so serious as might appear, "because the substitutes for textile fabrics invented during the war will gain in importance every year." The latest of these devices is the production from tree-bark of a fibre for weaving. The waste obtained in the process is said to be well adapted to replace coconut fibre.

A German Scout Biplane.—A German Pfalz single-seater biplane is described in a report prepared by the Technical Department, Aircraft Production, Ministry of Munitions. The construction is light and the design clean, and care has been taken to keep the fuselage of very good stream-line shape. The machine was found to climb to 10,000 ft. in 17½ min., and to 15,000 ft. in 41 min. 20 sec., the respective rates of climb being 360 ft. and 110 ft. per minute. The speed at 10,000 ft. was 102½ miles an hour, and at 15,000 ft. 91½ miles. The machine is reported to be stable laterally, but unstable directionally and longitudinally. It answers well to all the controls, but tends to turn to the left in flight. It is not tiring to fly, and is normally easy to land. The most novel feature is the fuselage, which is simply a light wooden framework, without any bracing, covered with two skins of three-ply wood arranged specially in different directions. The undercarriage is constructed of stream-lined steel tube, and the shock-absorbers are of rubber, which is somewhat unusual in German aeroplanes at present. The wings and wing bracing are a copy of Nieuport practice. The engine is a 160 h.p. Mercédès.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

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PROCEEDINGS OF THE SOCIETY.

SPECIAL LECTURES.

THE GERMAN "FREEDOM OF THE SEA."

By John Leyland.

Lecture III.—Delivered May 16th, 1918.

In the series of lectures of which this is the third and last the question of the freedom of the seas has been, and is being, treated from three points of view, or, perhaps one may say, in three periods of history. The general subject has been brought before the Royal Society of Arts by Mr. Fiennes, and the relation of the belligerent to the neutral in former wars has been dealt with by Sir Francis Piggott. It falls to me to lead you into a consideration of the much-discussed, but imperfectly understood, claim of the Germans as expressed in these days by German statesmen, and embodied in the proposals for the peace they desire. I need hardly say how surprising it is to us to hear the claim for the freedom of the seas urged so frequently by those who abuse it most. We shall investigate this question, and regard it also to some extent with relation to the declaration of President Wilson in his great address to the United States Senate on January 22nd, 1917. The freedom of the seas, as you will readily agree, continued untrammelled and unrestricted in time of peace, so much so, indeed, that it was not questioned or discussed before the war. It would be a great mistake, however, to conclude that it necessarily exists *per se*, and that if Germany were victorious it would continue to exist in any waters which that Power might control—let me say, in the Baltic, for example, or the Eastern Mediterranean.

It must be admitted that the expression or phrase of the freedom of the seas, as used by the Germans and others, has in it something vague and indeterminate. It may sometimes have been used with reference to the possibility of economic war following the clash of arms. Many people find great difficulty in attaching any precise significance to it. It gives rise to misunderstandings and doubts, and—dare I say it?—has been used on some occasions with the object of darkening counsel. The German Government, in its reply to the Pope's Peace Note, made a claim for "the true freedom and community of the high seas." The Austrian Emperor also declared, of the high seas, that "they rightly belong to all the nations of the earth."

Count Hertling, speaking in the Main Committee of the Reichstag, on January 24th, said there was no disparity between the German point of view and that of President Wilson. We know, in fact, how wide and deep the disparity really is. He added that, for the freedom of shipping, it would be highly important that strongly fortified naval bases on international routes, such as England possesses at Gibraltar, Malta, Aden, Hong-Kong, the Falkland Islands, and other places should be removed or dismantled—a suggestion to which President Wilson, on general grounds, would by no means subscribe, since also the Panama Canal has been fortified by the United States Government. The Imperial Chancellor made a special reservation with regard to President Wilson's limiting clause, whereby the seas would be free, except as they might be closed "in whole or in part by international action for the enforcement of international covenants." President Wilson, in an address before Congress on February 11th, adverted with some sarcasm to the fact that Count Hertling looked askance at any limitation of the freedom of the seas by international action in the interest of common order.

I have sought in vain for any clear, dispassionate and reasonable definition in German authorities of the meaning of the phrase as

used by them. Have the statesmen, jurists and merchants, who say the freedom of the seas is menaced by England, any definite facts in their minds, or are they saying one thing and meaning another? The former Imperial Chancellor, Dr. von Bethmann-Hollweg, spoke merely in general terms on the subject in August, 1915, when he sent a message to the United Press of America in the name of his Imperial master. "Far across the frontiers of Germany this peace for which we are striving, will," he said, "guarantee to all nationalities the freedom of the oceans." A few days later, at the opening of the Reichstag, he declared the securing of the freedom of the seas to be a German object, and he embodied in his remarks a protest against British domination. "For our own and other people's protection, we must gain the freedom of the seas," he said, "not, as England did, to rule over them, but that they should serve equally all peoples." Consciously or unconsciously he spoke as Napoleon had spoken before him. The now famous resolution of the Reichstag, carried by a majority of ninety-eight on July 19th, 1917, declared for an economic peace with the freedom of the seas assured. "Die Freiheit der Meere muss sichergestellt werden," were the words, but they were not further explained.

But, if we look in vain for a precise definition of the freedom of the seas, as demanded by enemy statesmen and politicians, we can determine at least what their phrase does not imply. It does not, and it cannot, imply a condition of things existing at sea in any times other than those of war. It would be manifestly absurd to connote the German freedom of the seas with the situation which exists in peace, for I cannot discover that the term has ever been used—save recently by German shippers and publicists—except with reference to the operations of war. The sea is the free and beneficent highway of the nations, unless or until it is disturbed by the oncoming of hostilities. It is the secure environment in which the nations live. It is disturbed neither by outrage nor by piracy. It is made secure by survey and charting, by pilotage and the lighting of coasts and waterways, and by the provision of everything that can conduce to the avoidance of the casualties which are incident to the career of the seaman. It may be described, as by a figure, as the atmosphere which the nations breathe. They are unconscious of it until it is shaken by the concussion and filled with the choking dust of an explosion of the fury of the nations raging against one another. The freedom of the seas exists unquestioned, unchallenged, and unrestricted in time of peace. It never has existed, and never can or ought to exist, in time of war. As long as belligerency exists on land, it cannot be banished from the seas. It is, indeed, a strange thing that the aspiration for freedom in war extends only to the sea, for no one has yet been found to maintain that the peaceful merchant and farmer shall go about their concerns undeterred in the very zone of war on land.

We are, therefore, brought to the conclusion that, when the enemy makes a demand for the freedom of the seas, his real object is, if possible, with the help of the neutrals, to shorten the arm of our Sea Power—to lessen its reach and weaken its stroke in the operations of war. If confirmation of this view be required, we shall find it in the writings of certain German naval officers, and before I go any further I will cite certain passages of very remarkable character. Rear-Admiral Carl Hollweg is the author of a very dexterous little volume, published in Berlin last year for propaganda purposes, which is entitled "Unser Recht auf den U-Bootskrieg." This is what he says with reference to the freedom of the seas:—

"It is our honest conviction that to-day we are fighting with the neutrals at our side, for their future rights on the sea. And therein lies the great significance of the U-boat warfare in the present struggle, that it will destroy the obsolete, harmful theory of the 'invincibility of sea-power,' which has hung like a sword of Damocles over the heads of the weaker sea-powers; and that it will tear the whip of hunger out of the hand of English naval despotism for all eternity."

The second extract is equally vigorous in its form. It is from an article on the same subject, contributed to the semi-official monthly *Ueberall*, by Lieut.-Commander Bierbrauer zu Brennstein towards the end of last year. He concludes thus:—

"For Germany there is only one 'freedom of the seas,' which is the liberation of the seas from the tyranny of England. England's outrageous power must be broken for ever. To achieve this end a strong and mighty Germany is required, and then the seas will be free. To achieve this, a strong and powerful German navy is also required. We must have defended naval bases in our colonies and also on the Belgian coast, where no Englishman may land with hostile intent. Germany will then be the real protector of the neutrals, and of the freedom of the seas. It must and shall be so."

Herr Winand Engel put the matter quite plainly, not beating about the bush at

all, in the Pan-German organ, *Das Grössere Deutschland*:—

"German policy is forced to secure for itself by all conceivable means domination over the world sea. I deliberately use the expression 'domination over the world sea,' and not the expression 'freedom of the seas,' which is common to-day. The latter expression is either dishonest or stupid. The sea is free to us only if we dominate it. If we do not dominate it, it may one day be closed against us."

Now this is a perfectly clear and honest avowal of a definite purpose. Grand Admiral von Tirpitz explained how this was to be brought about to Mr. Gerard, former American Ambassador in Berlin, just before the latter left Germany. "Our submarine warfare is going to bring Great Britain to her knees, and when we have her where she is to pay the price, that price will be the British Navy. With it and our own navy we shall then come to the United States and get what we want." What then, one may ask, would become of the freedom of the seas?

The Royal Society of Arts would not wish me to tarry longer in the heated atmosphere of these angry disputations and demands, but, if we are to understand the objects which are covered in some influential enemy quarters by the claim for the freedom of the seas, it is essential that we should be made acquainted with the pleas and arguments which are advanced.

We realise, among other things, also that fresh movements are afoot in that obscure region of what is known as International Law, where the belligerent and neutral face one another. It is a department of the Law of Nations which, beyond all others, requires and must receive illumination for the ascertainment and determination of principles, because it is now seriously contended, not only by the enemy but by some neutrals also, that the neutrals possess rights which may transcend in efficacy those of the superior naval belligerent. The obvious consequence of the acceptance of such a contention would be to weaken and cripple the naval belligerent in his operations against his enemy. This aspect of the question was fully dealt with by Sir Francis Piggott in the second of these lectures, and will not detain me here.

Before we go further, it is important to observe that the German freedom of the seas, strange as this may seem, is not incompatible with the operations of submarines ruthlessly attacking enemy and neutral alike, nor with the laying of mines by the Germans in areas where they may and do endanger shipping, both belligerent and neutral, on the highways of commerce. At the Hague Conference of 1907, Great Britain advanced every possible argument to bring about a limitation of the practice of mining, and a restriction of the destructive effects of mines, by proposing that if mines got adrift their construction must be such that they would become innocuous. Germany led the opposition to the proposed limitation, and was supported by Austria-Hungary and other Powers. Sir Ernest Satow on behalf of the British delegation, declared that the emasculated Convention which was arrived at was very unsatisfactory, and was not a final solution of the question. It took no account of the rights of neutrals or the principles of humanity. It imposed no restriction upon the belligerent from placing mines wherever he chose—in his own waters for defence, in the enemy's waters for attack, or on the high seas, whereby neutral navigation would inevitably run great risks and be exposed to serious disaster. Sir Ernest Satow intimated to the Conference that an act of this kind must not be considered lawful merely because a Convention had not forbidden it. The German representative, Baron Marschall von Bieberstein, repudiated with some warmth the idea that his country was inferior to any other in the quality of humanity—a remark which arouses strange reflections at the present time.

How little the real freedom of the seas has been in the minds of the Germans who claim it, and how little they have regarded the rights of humanity, was seen in the early days of the war, when a mine-layer, in the guise of a peaceful neutral merchant ship, scattered mines indiscriminately in the open sea on the main trade-route from America to Liverpool round the north of Ireland, whereby peaceful merchant ships were blown up with great loss of life. It was because of these wanton and reckless acts that the Admiralty adopted special retaliatory measures, and proclaimed a war area on December 2nd, 1914. How utterly regardless of the rights of belligerents and neutrals Germany has since shown herself by her scattering of mines, is too well known to need any recital here.

We are now free to pass on to a consideration of the larger question of the freedom of the seas in time of war, which is quite a different matter from the abuse of that freedom by those who claim it most vociferously. Their claims, we may be assured, will be urged on other grounds when the Peace Conference assembles.

They have spared no effort to bring neutral opinion to their side by holding us up to execration as violators of the principles they profess to uphold. It is unquestionable that a great prejudice has been aroused against us in the minds of neutrals, which may be deepened also by the recollection of certain of our acts in former wars, and by our long traditional claim to what was vaguely known as the Sovereignty of the Seas. Among the acts which have been charged against us as tyrannical and violent in our treatment of neutrals, was our seizure of the Spanish treasure ships, in October 1804, when Spain was yet at peace with us, though at that very time Napoleon was driving her to take up arms in his quarrel, and the captured ships were engaged in carrying wealth to the Power which was about to range herself among our foes. There was our seizure of the Danish fleet in 1807, which was, indeed, a violation of neutrality, but was justified by the knowledge we had gained of the damnifying clauses of the Treaty of Tilsit, and the act was followed by restitution of the Danish fleet, while Denmark was saved from Napoleon, the Baltic was kept open for trade, Sweden was enabled to preserve her independence, and the Tsar was led, as a measure of prudence, to give peace and a constitution to Finland. There has, in fact, been a sufficient explanation of every act which has been regarded as a violation by us of the Law of Nations. In this present war, the restrictions which we have set upon neutral navigation have been in part in pursuance of undoubted belligerent rights, which forbid the neutral to carry or transmit supplies to the enemy, and in part have been due to considerations arising from the necessary protection of vessels from destruction by submarine attack.

Having now arrived at a general conception of the character and objects of the German claim to the freedom of the seas, we may say something about that relic of mediævalism — the old English claim to the sovereignty of the seas, not because it possesses any real modern significance, but because, in association with the claims of other nations to the possession of certain parts of the seas, it became the subject of a famous controversy, wherein the great Dutch legist, Grotius, arose as the exponent of the freedom of the seas from such assumptions of control as were applied practically in the restriction of navigation, trading and fishing, and especially because also the authority of Grotius, by a palpable misuse of history, has been used by modern Germans to express their condemnation of our imputed tyranny at sea. The freedom of the seas which the Germans seek would have been abhorrent to the mind of Grotius, and an intolerable heresy. To cite the juridical interpretation of the *mare liberum*, based upon conditions which have long since passed away, and to urge its application to the undermining of our sea-power, is to travesty the meaning of history. The free sea of Grotius had to do only with the prosecution of trade and navigation in the normal times of peace. He never argued against the law of contraband or the capture of private property; he maintained both. Our claim to a certain sovereignty of the neighbouring seas was based on our purpose, manifested in the Ordinances of Richard I., Edward I. and Edward III., of maintaining peace and justice "among the people of all nations whatsoever passing through the sea of England." A salute to our flag was exacted, but we were for centuries the persistent exponents of the doctrine of the free seas in all seasons of peace. We maintained it, and set out to "punish delinquents, and afford redress to the injured."

Those were ages in which there existed the idea of legal possession of the sea. Venice laid exclusive claim to the Adriatic, Genoa and France to parts of the Western Mediterranean, Denmark and Sweden to the Baltic, Spain to the Pacific and the Gulf of Mexico, and Portugal to the seas south of Morocco and to the Indian Ocean. Such ideas inevitably tended, as time went on, to attempts to restrict by legal means the free use of the seas. Henry VII., strongly opposing such restrictions, concluded with Philip, Archduke of Austria and Duke of Burgundy, in 1496, the famous treaty of the Intercursus Magnus, which gave to fishermen of all nations leave to fish where they would without need of licence or safe conduct. Elizabeth asserted for England with the utmost vigour the right to navigate the open seas against the exclusive policy of Denmark and Spain. Her reply to the Spanish Ambassador in 1580, her instructions to her own Ambassadors in 1602, and her declarations on other occasions, lacked nothing of definiteness or emphasis. She could not have been other than an exponent and advocate of the freedom of the seas in times when English seamen were breaking Spanish monopolies, and carrying their shipping into every sea. At its very birth our sea-power found an abiding inspiration, and fixed for ever the traditions of the Navy, in an age fragrant with the breath of free intercourse, of the free sea, and of political

independence, which are our glory, and the best gift we have given to the world.

Grotius set out mainly to demolish one by one the pretensions of the Portuguese to exclusive trading and navigation in the waters of the Indies, which the redoubtable van Heemskerk had struck at by warlike measures in seizing Portuguese shipping. His arguments did not prevent the attack and defence of commerce from being the essential feature in the three Dutch wars. The right of warlike capture was in full operation, and unquestioned. No legislators of those times ever thought of applying theories on sea dominion and fishing and trading rights to the conditions of war. Charles I. did, indeed, resent the claims of Grotius, and entered a protest through his Ambassador at the Hague. He caused Selden to make his famous reply, but saw clearly the point that he could not command the sea so much by the discourse as by "the louder language of a powerful navy, to be better understood when over-strained patience seeth no hope of preserving her rights by other means." Cromwell's Navigation Act established a restriction of free navigation, but, as Twiss remarks, "all these pretensions are now a matter of history." Professor Perels, the eminent German authority on International Law, who was formerly a professor at the Naval Academy at Kiel, and afterwards Counsellor of the German Admiralty, speaking of the seas in peace, lays down the indisputable principle that the use of the sea, with a political, industrial or scientific object, belongs to all nations and cannot be refused to any of them.

We must nevertheless recognise and understand the fact that in all the wars of the past two centuries we have been denounced as exercising harsh dominion on the waters, and that the neutrals have been marshalled against us on many occasions. It was during the Seven Years' War that we first began to be described as the "tyrants of the sea," though traces of the same imputation may be found earlier, as in the famous political testament of Richelieu. The victories of Hawke and Boscawen, the downfall of French rule in Canada, the breaking of French power in India, the immense increase of commerce which we reaped, and the policy by which we rigorously employed our belligerent rights against offending neutrals, made us the first of world Powers, though it caused us to be less loved than we were feared. Those nations which had sought to use the advantage of trade with our enemies, began thereafter to take counsel amongst themselves against our universal control of the sea. Pitt foresaw that the Northern Powers might unite in armed alliance to protect their trade, and in 1780 the first Armed Neutrality came into being. The object of this movement and of the Armed Neutrality of 1800, was to set a limit to the full exercise of our maritime power, and the contentions put forward were substantially those embodied in the modern German claim, stripped of its wild absurdities. Sir Francis Piggott has very ably analysed the genesis and character of the Armed Neutralities in the previous lecture, and therefore nothing shall be said about them here to-day.

It is, however, most important to understand the attitude of Napoleon in the period before the second Armed Neutrality was concluded, because of its close analogy to that of Germany at the present time, especially with relation to rebellion against our sea supremacy which lies at the root of the protest. Peace was ever on Bonaparte's lips, on grounds of reason and humanity, but, as M. Driault says, in his book "La Politique Extérieure du Premier Consul," there was in his expressions "plus de sensiblerie que de sincérité." From the very battlefield of Marengo, on June 16th, 1800, he declared to the Emperor and King that the equilibrium of Europe was not menaced by France, but "by the power of England, which had so seized upon the commerce of the world and the *empire des mers* that alone she could resist the united navies of the Russians, Danes, Swedes, French, Spanish and Dutch." This appeal was directed primarily to the isolation of England and the destruction of her sea-power.

The First Consul continually exerted himself to represent us as the tyrants of the sea. The official papers of the French navy at the time were adorned with a representation of the Republic grasping the helm of a vessel on which —in bold characters—were inscribed the words "Liberté des Mers." It was mainly by his advocacy and denunciation that he brought the United States into alliance against us by the Convention of September 30th, 1800. In his "allocution" to the deputies of the Hanseatic towns on March 17th, 1811, he declared, "Il faut reconquir à la fois le droit des nations, la liberté des mers, et la paix générale."

We are indebted to the Poet Laureate for a masterly translation of Fichte's famous account of Napoleon, with Freedom of the Seas on his lips and Overlordship of the Seas in his heart. It should be marked well in these days when

the Germans are making their loud demands. Napoleon, says Fichte, was endowed with the two elements of heroism—calm perspicuity of intellect and firmness of will, but these were irradiated with no inkling of the moral vocation of humanity, which seemed to him a blind lump, either stagnant or moving in disorder. He thought that rare spirits were born at long intervals, "the like of Charlemagne, and of none other but himself after Charlemagne," and thus, deeming himself a master-spirit, "the very godlike and holy, the first principle of motion in the world's history," he set great forces in action.

"And the most immediate, indispensable tool of his ordinance was at this moment the 'Freedom of the Seas,' as he said, but thereby intended the 'Overlordship of the Seas' in his own hands; and for this most important aim, determined by his world-law, all the happiness of Europe must be sacrificed, all its blood flow—since for that purpose only was it there; and this mighty world-plan, which indeed overstretched the scope of one life-time, should be carried on after him by his dynasty, so long as until, maybe in another thousand years, another inspired hero might spring up, a new incarnation of the type of himself and Charlemagne."

At this point I will introduce to you a well-known German—no other than the famous Schiller—at whose curious whim we may smile. The poet, at the opening of a new century—the nineteenth—addressed certain verses, which are ascribed by the critics to his third period, to a friend, mainly on the subject of freedom. He appears to have been infected with the glamour of the Napoleonic ideals, at a period before his country had been severely chastised at Jena and Auerstädt, and this is how he speaks of us Englishmen. You will allow me to render his verses in the form of prose.

His trading fleets sends the Briton out, greedy as the arms—he means the tentacles—of an octopus, and he will close the realm of the free Amphitrite as if it were his own house. To the never yet seen stars of the South Pole—I fear the explorations of Cook, Flinders, and others must have ruffled the poet—he carries his restless, unbounded course. He examines every island and every distant coast—only Paradise he does not reach! *

* "Seine Handelsflotten streckt der Britte
Gierig wie Polypenarme aus,
Und das Reich der freien Amphitrite
Will er schliessen, wie sein eignes Haus.

"Zu des Südpols nie erblickten Sternen
Dringt sein rastlos ungehemmter Lauf;
Alle Inseln spürt er, alle fernen
Küsten—nur das Paradies nicht auf."

—"Der Antritt des neuen Jahrhunderts."

Let us ask how our country has used that supremacy at sea which, throughout all the long centuries of our history, has been to us both sword and buckler? Have we used it to close or menace the pathways of the sea? Have we not rather used it on many occasions to hold it for the protection of the nations which have lain beyond it? The Germans, haunted by the shadow of their own militarism, have charged us with what they have called "Marinismus" or "Navalism." Once more, as in the long war with the French Republic and Empire, we are denounced as the tyrants of the sea, though the truth is palpable and beyond dispute that, with a deep instinct for freedom, and a wise political sense in our dealings with the nations, we have grasped the meaning of the sea for the benefit of the world. Its great traditions are in our blood; its potent influence is in all we have done; we have sought and discovered new pathways at sea; countless Englishmen have expended their lives and their treasure that the world might enjoy the advantages and riches, the profitable intercourse, and the free institutions which the safe sea can bestow. We have made the world as free to other nations as to ourselves. The British Navy has lain between many a country and the militarism that would have subjected it. The States of Central and South America owe their independence to our "Navalism," and the Monroe Doctrine itself was established and maintained because the British Navy made it effective by protecting the old possessions of Spain and Portugal from aggression.

Let Admiral Mahan speak of what the British Navy has achieved in maintaining the real freedom of the seas.

Why, he asked in one of his later articles, why do English innate political conceptions of popular representative government, of the balance of law and liberty, prevail in North America from the Arctic Circle to the Gulf of Mexico, from the Atlantic to the Pacific? And he answered that it was because the command of the sea, at the decisive era, belonged to Great Britain. In India and Egypt administrative efficiency took the place of a welter of tyranny, feudal struggle, and bloodshed, achieving thereby the comparative welfare of the once harried populations. What underlies this administrative efficiency? The British Navy, he answered again, assuring, in the first place, British control, and thereafter communication with the home country, whence comes the local power without which administration everywhere is futile. What, at the moment when the

Monroe Doctrine was proclaimed, insured beyond peradventure the immunity from foreign oppression of the Spanish-American colonies in their struggle for independence? It was, he said, the command of the sea by Great Britain.

The liberation of the seas for the free use of the nations has, in truth, been a progressive, consecutive purpose of our country. The Navigation Act, long maintained, had an economic purpose, and political economists in those times never wearied in pointing out the folly of restrictions of commerce. In 1826 the Act was repealed, more liberal rules were introduced, and in 1854 the coasting trade of England was thrown open to foreign vessels. The Germans forget that, under the much-contemned shield of the British Navy, the immense trade built up by the Hamburg-Amerika and Norddeutscher Lloyd lines, flourished exceedingly, altogether unfettered by any British action or exclusive policy whatever.

We turn now to the attitude of President Wilson and of American jurists to the question of freedom of the seas. When the President proclaimed the freedom of the seas to be of sovereign importance to his country, we well know that the freedom he had in mind had nothing in common with the so-called freedom which the Germans have demanded.

The conflict upon which he entered was directed, he said, to the suppression of a "warfare against commerce," which was, in effect, a "warfare against mankind" and "a war against all nations"—a war divested of all regard for the scruples of humanity, and of all "respect for the understandings supposed to underlie the intercourse of the world." He described German submarines as "in effect, outlaws," and as deserving to be dealt with as such. They had struck at the basis of "International Law," and had done so with a license—the words are not his, but those of Grotius—"of which even barbarous nations would have been ashamed."

The principle of International Law, said the President, had its origin in an attempt to set up some law which would be respected and observed upon the seas, where no nation had the right of dominion, where lay the free highways of the world. By painful stage after stage had that law been built up, with meagre results, indeed, after all has been accomplished, always with a clear view, at least, he declared, of what the heart and conscience of mankind demanded. This minimum the German Government had swept aside under the plea of retaliation and necessity, and because it had no weapons which it could use at sea except those of the submarine and mine.

President Wilson, at an earlier date, had imagined a condition arising from the war in which bitterness would not be implanted in the heart of any humiliated nation, in which the peace would be arrived at between equals, and in which a "freedom of the seas" would exist such, he said, as "in international conference after conference, representatives of the United States have urged with the eloquence of those who are the convinced disciples of liberty."

There can be no question that the President was referring, under the name of "freedom of the seas," to the immunity of private property at sea, save contraband of war. This matter is of very high significance, and its significance is likely to become more evident when the Peace Conference assembles at the close of the war. For Count Hertling claimed practical identity of view with the American President on the "freedom of the seas," except that he questioned the limitation proposed to be set up by the President, in that passage where the latter said the seas might be closed in whole or in part by international action for the enforcement of international covenants. The reference was doubtless to action possibly to be taken by the proposed League of Nations.

When the German claim is stripped of its absurdities, accompanied as it is by multiplied denunciations of ourselves, and is seen in its nakedness, it is revealed as nothing other than a demand for the immunity of private property at sea, or perhaps for the immunity of neutrals trading with belligerents—the immunity, for example, of any neutral willing in this present war to carry supplies to Germany. This may be the simple legal element of the claim. Count Bernstorff was reported, in September, 1915, to have indicated this as the actual meaning of the phrase—that "private property at sea should be immune from attack by naval forces." But the simple legal element which may be advanced at a Peace Conference is not enough. It must be regarded with suspicion, for, as Mr. Balfour has said, these missionaries of maritime freedom "are the very persons who preach and who practise upon land the extremist doctrine of military absolutism." They are the persons also who, by a strange contradiction of their own demands, make use of the submarine as a barbarous assailant of the freedom of the seas.

It must be admitted that the Americans have been very consistent in their attitude towards the question of the immunity of private property, save contraband, in maritime war. Benjamin Franklin procured a clause to be inserted in the Treaty between the United States and France in 1785, which granted this immunity. President Monroe took the same view in 1823, President Pierce in 1854, President McKinley in 1898, and President Roosevelt in 1903. This was the attitude, too, of the United States at the Paris Conference of 1856, and the same provision was embodied in the Treaty between the United States and Italy in 1871. At the Hague Conference of 1899 the following proposition was brought forward in a memorial presented by the representatives of the United States :—

"The private property of all citizens or subjects of the signatory Powers, with the exception of contraband of war, shall be exempt from capture or seizure on the high seas or elsewhere by the armed vessels or by the military forces of any of the said signatory Powers. But nothing herein contained shall extend exemption from seizure to vessels and their cargoes which may attempt to enter a port blockaded by the naval forces of any of the said Powers."

At the Conference of 1907, Mr. Choate made fresh proposals for the immunity of private property, and it is remarkable that amongst those who supported him were the German delegate, Baron Marschall von Bieberstein, and the Austro-Hungarian and Turkish delegates, all representatives of the present enemy Powers, while Great Britain, France, Russia, and Japan, Allies in the war, were all for the retention of the ancient right. Now that the great democracies of the West have grown so closely together, we may believe that the United States will not tarry longer in such uncongenial company as was ranged in this controversy with Mr. Choate. At least, it is certain that the League of Nations would never grant immunity at sea to the private property of a transgressor of its ruling.

It is right to observe, however, that the immunity of private property at sea has found many supporters in old and modern times. The Abbé de Mably and Azuni may be mentioned among the older writers. Brougham, not realising the great difference between sea and land warfare, was willing to conform the practices of the former to those of the latter. Palmerston seems to have toyed with the idea. Cobden was inclined in the same way, and John Stuart Mill, too, though the reasons with which the latter enforced his view read with strange unreality in the light of the present war. That is also true of all such proposals. Most of the German authorities are in favour of the immunity of private property at sea—Heffter, Bluntschli, Gessner, Von Holtzendorff, and others. Their attitude was inevitable in view of the situation of their country, which had all to gain by the proposals they favoured. Perels, however, gives an able summary of the reasons for maintaining the right of capture in these significant words: "War is a necessary evil; beyond question the confiscation of private property at sea is a necessary evil also; a nation whose principal military strength resides in its naval forces, cannot renounce this right without compromising its means of defence. The confiscation of the ships and goods of the enemy is, like the fighting on land, the object of maritime warfare. The latter has a character less cruel, without, however, weakening its effect, which is to compel the adversary to submit. By conceding complete freedom to the enemy's ships, he would obtain a great advantage, for these ships do not always confine themselves to inoffensive acts. Maritime commerce and commerce on land are two very different things; there are relations between the war fleets of a state and its merchant marine; merchant vessels may often serve the purposes of war, for which their crews are well fitted."

Although this eminent German authority was inclined to the views of Bluntschli, these arguments—which he gives dispassionately on the other side—seem unanswerable from the point of view of the supreme naval Power, and they are strengthened a hundredfold by the events of the present war. It has been argued that warfare against commerce at sea, which aims at impoverishing the civil population and arresting its industry, should be abolished. Why, it has been asked, should a soldier be forbidden to seize 1,000 bushels of wheat, unless he absolutely needs the supply and pays for it, while a naval officer may seize any merchant ship, and whatever may be in her — bullion, jewels, wheat or anything else—without the least suggestion that he has any real need of these things? What is the difference between 1,000 bushels of wheat in a ship and 1,000 bushels in a barn? The answer to this, and to other like questions, is that sea warfare differs entirely in its character and its laws from land warfare. How, in this war, have not the forecasts been falsified of some persons who have said that private property is

respected by the laws of land warfare, and not respected by the laws of war at sea ? An army can occupy a country, use its resources, make exactions from its people, and employ against its populations the extremities of military cruelty, under any kind of pretext, and in conformity with a "Kriegsbrauch" or other instrument. It can besiege cities, cut off their water-supplies, lay waste the surrounding tracts, reduce their inhabitants to famine, and bring them to misery and destruction. This invading army may be able to pursue the national army, and destroy it in battle or cause its surrender, or drive it over the land frontier of its country. A fleet cannot do any of these things. It can occupy nothing, and has no power of land action outside the range of its guns. It has no means of bringing the main forces of the enemy to action, if that enemy, as in the present war, chooses to remain in fortified ports. All it can do is to hold the communications of the enemy and maintain its own. If there were no capture of private property, naval operations would become immeasurably weaker as a means of endeavouring to force an enemy to submit. A fleet operates in an element that gives it a long reach, and enables it at times to exercise influence where it is never seen. There is nothing comparable in its action to the operations of an army.

That is why the British Empire can admit no so-called "freedom of the seas." The right of blockade and capture will be abandoned only with the abolition of war itself. The abolition of capture would mean in practice the prohibition of effective naval warfare altogether. "For two hundred years," wrote Admiral Mahan in his "Influence of Sea Power on History," "England has been the great commercial nation of the world. More than any other her wealth has been entrusted to the sea in war and in peace ; yet of all nations she has ever been most reluctant to concede the immunities of commerce and the rights of neutrals. Regarded not as a matter of right but of policy, history has justified the refusal, and if she maintain her Navy in full strength, the future will doubtless repeat the lesson of the past." We uphold the doctrines of blockade, capture and exhaustion, because their efficacy has been exemplified many times by the logic of facts, and is exemplified a hundredfold to-day. We naturally argue that a serviceable weapon cannot be abandoned until circumstances emerge over which we have no control that may render it obsolete.

I will conclude by quoting some pertinent observations which Mr. Balfour has made on the subject of the false freedom of the seas. He rightly warns us that, in the stress of war, or for the purpose of a hostile belligerent, so-called freedom of the seas, if accepted by the nations in any form, might in a single day be overthrown, and violence might find us unprepared.

"Could anybody," he asked, "suggest after our experience in this war, after reading German histories and German theories of politics, that Germany would be prevented from taking such a step by the mere fact that it was a breach of international treaties to which she was a party ? She would never hesitate—and the only result of the cession by the pacific Powers of their maritime rights would be that the military Powers would seize the weapon for their own purpose and turn it against those who had too hastily abandoned it. Thus we are forced to the sorrowful recognition of the weakness of International Law, so long as it is unsupported by international authority. While this state of things is permitted to endure, drastic changes in International Law may well do more harm than good ; for, if the new rules should involve serious limitations of belligerent powers, they would be broken as soon as it suited the interests of the aggressor ; and his victim would be helpless. Nothing could be more disastrous. It is bad that law should be defied. It is far worse that it should injure the well-disposed. Yet this is what would inevitably happen, since law unsupported by authority will hamper everybody but the criminal."

Mr. Balfour put this point in the clear light in which it must be regarded. We cannot throw away our shield and leave to the enemy his sword. We will not bow our heads to the stroke. We will make the seas really free to all men. We will not give them over to bondage under the name of a false freedom. It will, indeed, be an evil day for us if ever we are beguiled by empty phrases into listening to specious pleas for a deceptive freedom of the seas, whereby we may shorten the reach or weaken the stroke of that Navy upon which, in the noble words of the Naval Discipline Act, "our wealth, prosperity and peace depend."

Admiral Sir Edmond John Warre Slade, K.C.I.E., K.C.V.O., who presided at the last lecture, read the following statement :—

The interesting and important address which we have just listened to with so much pleasure

from Mr. Leyland, completes the course of three lectures on the "Freedom of the Sea"; and, with your permission, I will endeavour to review the subject as it has been presented to us by the three eminent men who have dealt with it.

In tracing the historical sequence of events, Mr. Fiennes has clearly demonstrated the important part the sea has held in the history of the world from the earliest times. He has shown that when man was first able to use the sea for purposes of transportation, there was perfect freedom for everybody. No law existed, and each man did as seemed best to himself within the measure of his own strength. Gradually combination came about, and as the arts of shipbuilding and navigation grew, we find sometimes companies, sometimes nations, banding together for protection and the furtherance of mutual trade. The sea was a highway and, like the highways on land at that time, people using it had to trust to their own right hand to maintain their right to travel along it in safety.

It very soon became evident that that body, whether an organised State or bands of freebooters, which controlled any portion of the sea exercised thereby a powerful influence on all persons or communities using that sea.

We thus find Greeks, Romans, Phœnicians, and Carthaginians fighting for the mastery of the Mediterranean, and the power that held it was for the moment supreme in the regions that depended on it for communications and trade. Similarly, in the north the Vikings exercised great influence both in this country and on the northern coasts of Europe.

Later, in the Middle Ages, England, France, Spain, Portugal, and the Netherlands fought each other for the same prize until, finally, at the beginning of the nineteenth century, were left only France and England. From the earliest days the object in every case was the same—to obtain the control of trade. In the earlier days the endeavour was to levy tolls on all trade wherever it could be struck at, and it was only in the later Middle Ages that this was seen to be uneconomical, and trade came to be protected on the high seas.

In wartime in all ages the control of the sea-lines of communication has had a profound effect on the war. The sea forms, and always has formed, the quickest route by which supplies, stores, and reinforcements can be carried from one point to another, so long as the countries engaged are in any way dependent on the sea. History tells us that in every war where maritime interests have been involved, the scales have been heavily weighted in favour of the side holding the control of the sea.

In the second lecture, Sir Francis Piggott has dealt with the subject from the point of view of the international lawyer.

Municipal Law has its origin in the endeavour of the community to protect the weak from the capricious action of the strong, and to introduce regularity into the conduct of daily life. International Law has the same idea as the basis of its inception, but with this difference that, while Municipal Law has the sanction of the State behind it, there is no sanction to support International Law, and this defect is fatal to its efficiency.

Endeavours have been made to correct this weakness by treaty agreement, and by tacit acceptance of precedent, each nation trusting to the honour of the others to abide by these understandings and to respect ancient customs. But the lesson of the war is the same as that taught by the history of all communities in the matter of Municipal Law and custom. There is a section of the community which will respect no custom nor any law unless force or self-interest drives it to do so.

The difficulties of arriving at any agreement on the principles of International Law have been far greater than those that have had to be surmounted in dealing with Municipal Law. There is no sanction that can be appealed to, and there are two distinct and antagonistic sets of interests to be reconciled, namely, those o the group of nations whose interests are continental and those whose interests are maritime. According as the Maritime Group or the Continental Group has been uppermost, so the ideas regarding the true principles of International Law have varied.

At the end of the great wars of the last century the Maritime School was in the ascendant. The long years of peace that followed 1815 were broken only by minor wars, in which the interests of the Maritime Powers were identical with those of the Continental Powers—namely, to facilitate by every means the trade with the belligerents. It thus came about that vital principles, the maintenance of which led us to the Battle of Copenhagen, were forgotten, and the protection of the neutral was considered more important than the maintenance of the rights of the belligerent. To this we owe the catch-words, "Free ships, free goods," which have always been the leading idea of the Continental School, and the negotia-

tions finally resulted in the signing of the Declaration of Paris.

The story of the negotiations leading to the Declaration of Paris shows very clearly how this has all come about. The Maritime Group, as represented by Great Britain, was faced with a dilemma. For reasons which we cannot consider here, she wished to enter into an offensive alliance, for the prosecution of the Crimean War, with the Continental Group as represented by France. The maritime interests in this war were not vital, and the real importance of them was forgotten except by a few. The politician of the day was obsessed by what I may call "The trade for all and anything for trade" doctrines, and could not see that the abandonment of principles, which we had found to be vital half a century before when we were fighting for our lives, would be equally vital when the trial came again. So he capitulated to the Continental School; but, as Sir Francis has pointed out, even then he was afraid of what he had done and, so far as he could, he carefully hid his actions from the knowledge of the country.

Apply this argument to the present war. We have the same two Powers in alliance, using the word in its broad and not in its technical sense, but the maritime interests now are as vital to the Continental as they are to the Maritime Power, with the result that the ideas of the latter have prevailed, and we have for the moment reverted to the position as it was in 1815. The antagonism between the two schools of thought remains, but vital necessities for the time have prevailed. When the world returns to its normal condition of peace, the conflict will revive once more, and we can only hope that our statesmen of the future will be more far-seeing and more courageous in defending our rights than those of the past.

Let us turn now to what we have heard to-day of the views of Germany. In this war she is whole-heartedly of what I have called the Continental School of thought, and she considers that there are no maritime rights at all if they interfere with her ideas of the proper prosecution of the war. All maritime rights that would assist her she upholds, while those that would not she condemns. Germany now condemns all the pretensions of the Maritime Powers as represented by the Allies; but, if she wins, she intends to enforce them, and more, so that the seas shall become nothing but a German lake. She understands the meaning of the pressure of sea-power from bitter experience, and she is determined to apply that pressure far more ruthlessly than we have ever done, if only she can get the upper hand. As pointed out by Mr. Leyland in the quotation he gave us, she is aiming at nothing short of the domination of the sea, and to understand what German domination would mean we have only to look at the countries that are now under her power.

Time does not permit my referring to Mr. Leyland's interesting arguments about the right of capture of what is called "Private Property" at sea, but that right lies at the root of all that is claimed for sea-power, and can no more be abandoned than we can give up our Fleet.

Now may I suggest to you, very shortly, a reason for the existence of these divergent views, and also for the necessity of maintaining our point of view against all adversaries?

There is no question of the freedom of the seas in peace. We must, therefore, conclude that the whole claim is directed to freedom of the seas in war.

The importance of lines of communication is apparent to all, and if any confirmation is required we have only to look at the works constructed by both sides during the war to keep the fighting line duly nourished. The sea is only a link in the lines of communication, but is a very important one, and if it can be interrupted it is a most serious blow at the efficiency of the side on which it is cut. Now the Central Empires are not self-supporting, and they are dependent on the sea, to a greater or less degree, for provisions and raw materials. For the Allies the sea is even more important than for the Central Empires. Geographically the lines of communication are the same for both sides, and, therefore, if they are controlled by one side the other side loses them. It is therefore necessary, in default of sufficient strength to keep the control, to attempt by agreement and treaty rights to redress the balance, but German treaties are one-sided—Germany may keep them, but the other party must adhere to them.

There is nothing analogous in land fighting except when a district or a town is surrounded and cut off from its base, but no sane individual, least of all a German, would argue that there should be conventions allowing free neutral trade with such a district, and yet this is what in effect is demanded in the German claim for the freedom of the seas. The issue may be surrounded with all kinds of sophisms such as there is no overlordship in the sea, etc., but the plain issue is this—the sea-line of communica-

tion is vital. It is the same for both sides. Therefore if one side is master of it the other loses it. Therefore the weaker side at sea must try to bluff the other out of the position of advantage by every possible means.

From this it becomes clear why there are two schools of thought—the Continental and Maritime. The former, the weaker at sea, wants to neutralise the natural advantages of the latter by agreement, if they are foolish enough to walk into the trap. And this is what is meant by the German freedom of the sea. The latter, unless they wish to court disaster, must maintain their full belligerent rights intact.

I have not mentioned contraband, as it is only a detail and does not affect the underlying principle.

Finally, let me say a word about the possibility of any real agreement on the subject of the freedom of the sea. It is clear that the acceptance and observance of a code of maritime international law is the first step to be taken, because without a code of law accepted and obeyed by all freedom becomes anarchy, and we revert to the conditions outlined by Mr. Fiennes at the beginning of his lecture. The difficulty is the absence of sanction, and when we have to deal with a nation that deliberately says "necessity knows no law," and deliberately sets herself to break every convention she has entered into with regard to the rules of war if she considers it to be to her advantage to do so, and then glories in the fact because she claims that she thereby increases her moral superiority over her enemies who have adhered to their engagements, it is hard to see any way out of the difficulty.

There is, however, this series of possibilities, which, I must confess, are somewhat Utopian.

1. To form a league of nations. A possibility, perhaps.

2. To codify the laws and customs of the sea. Almost an impossibility, seeing the conflicting interests involved.

3. Every nation that joins the league to agree that in case of breach of any of the laws agreed upon, she will join with her co-signatories in declaring war upon the offender if reparation is refused.

At present, so far as I can see, in this way and in no other can we hope to arrive at the freedom of the seas, but it will not be the German freedom of the sea. They will then be free within the limits of the agreed laws, and in case of war there will be only one set of interests to be considered, namely, that of the belligerents, because, *ex hypothesi*, there will be no neutrals. But when we arrive at this we shall be within measurable distance of the Millennium.

WOLFRAM ORE AND TUNGSTEN.*

Tungsten is a metal of very high specific gravity and high melting-point. It is used to some extent for filaments of metallic lamps, and in large quantities as an alloy with steel. It has, even in comparatively small proportions, certain hardening and magnetic effects, and in large proportions, *i.e.* from 12 per cent. to 22 per cent., it has a peculiar property of giving a material for cutting tools which retains its hardness at high temperatures. The use of this material allows the speed of machines and depth of cutting to be increased far beyond what was possible with older forms of tool steel. Tool steel of this class has become an absolute necessity of modern engineering. When tungsten is mentioned in this report it refers both to tungsten powder and ferro-tungsten. Tungsten metal powder and ferro-tungsten are the basis of the manufacture of: (1) high speed steel; (2) magnet steel; (3) other tool steel containing tungsten. The percentage of tungsten used varies: (*a*) in high speed steel, 12 per cent. to 22 per cent.; (*b*) in magnet steel, 3 per cent. to 6 per cent.; (*c*) in other tool steel, 1 per cent. to 10 per cent. The other uses in this country for tungsten are: (1) electric lamp filaments; (2) contacts for magnetos in place of platinum; (3) in the form of tungstate of soda for fireproofing fabrics; (4) other minor uses.

The amount of high speed and other tungsten steels now being manufactured in this country under war conditions is approximately 20,000 tons a year, which is being distributed as follows: in England, 8,000 tons; in Russia, 3,500 tons; in the United States of America, 2,500 tons; in Japan, 1,000 tons; in Canada, 1,000 tons; in France, 2,000 tons; in Italy, 1,000 tons; in Australia, New Zealand and South Africa, 700 tons; to other Allies and necessary Neutrals, 300 tons, calling for about 3,000 tons of metallic tungsten or its equivalent in ferro-tungsten.

In peace time the quantity of high speed steel made by this country may be approximately taken at 40 per cent. of the above amount. High speed steel is used for: (1) engineers' tools, such as turning tools, planing and slotting tools; (2) twist drills, reamers, taps and screwing dies; (3) metal milling cutters, cold iron saws, and shell making tools; (4) valves in motor and aeroplane engines and magnetos.

The raw material from which metallic tungsten and ferro-tungsten are made is wolfram ore, alternatively described as wolframite or wolfram concentrates, which is mined largely in the British Empire.

* Report of Departmental Committee on the Engineering Trades after the War. [Cd. 9073.]

[A table given here indicates the chief sources of supply of wolfram concentrates and the average quantities shipped from the various countries in 1910, 1911, and 1912. Out of 8,639 tons produced in 1912, approximately 3,800 tons were produced in the British Empire. The production from Burma is increasing rapidly.]

The world's figures for 1913 are not available in their complete form, but the figures of the British Empire since then up to 1915 are recorded at the Ministry of Munitions. The output from the British Empire for the year ending August 31st, 1916, was 4,600 tons. The Committee is informed that as the result of war conditions there has been an abnormal increase of the output of wolfram ore n the United States, where the amount for the six months, January 1st to June 30th, 1916, is reported at 3,750 tons. It requires practically 2¼ tons of wolfram concentrates to produce one ton of tungsten.

At the outbreak of the war no tungsten powder was being made in this country. At least three manufacturers were making ferro-tungsten on a small scale. The greater part of the wolfram ore produced appears to have passed through this country. The bulk of it found its way to Germany, where the manufacture of metallic tungsten powder was carried on chiefly in association with large chemical works from which the necessary supplies of hydrochloric acid and other chemicals could be obtained economically. The tungsten powder was then sold by Germany to this country, and was used by steel makers for the manufacture of high speed steel, of which considerable quantities were exported to the United States, France, Germany, etc. Tungsten powder is also made in the United States of America and ferro-tungsten in France. There appears to have been no reason in the past, apart from organised German competition, including price cutting, why tungsten metal should not have been produced in this country. The value of the ore produced annually in the British Empire is estimated at £1,250,000; the value of the tungsten refined from this ore is estimated at £2,000,000, and the value of the high speed and other steels made from this tungsten in the British Empire is estimated at £7,500,000, all at war prices. High speed steel makers were content, before the war, to rely upon German supplies which were of satisfactory quality, and the trade, in spite of its importance, had not hitherto received full attention from English manufacturers. On the declaration of war the want of tungsten became immediately apparent. The manufacturers' stocks held here were practically three months' normal supply. The Admiralty took steps to ensure that all wolfram ore produced under the British flag was sent direct to this country. Reduction works were started, and there are now some eight or nine works in this country producing the requirements of the trade. It would appear essential, from the point of view of national safety, that the Empire should not again run the risk of being without tungsten metal at a momentous crisis, or during normal times. The present British manufacturers of tungsten doubt their ability to continue in the trade after the war in competition with German manufacturers —though this is not the unanimous opinion of those now engaged in manufacturing. It is apparent that under the British flag there is likely to be sufficient supply of wolfram ore for British requirements.

In order to supply the high speed steel which is necessary for the security of the nation in times of war, and for its prosperity in times of peace, it is necessary to provide tungsten in sufficient quantities, or its equivalent in ferro-tungsten. To do this two conditions are essential: (1) sufficient ore supplies; (2) works in the country capable of reducing the ore. As to the first condition, it appears that so large a proportion of the world's wolfram ore is produced in the British Empire that the object would be secured if British works had a first claim to the ore produced in the Empire. As to the second condition, sufficient works have been created in this country in the stress of war to meet all likely requirements, and if these works are maintained and kept efficient it appears only necessary to prevent the trade from being crushed by organised attacks by their competitors abroad, either by underselling or "cornering" ore supplies.

[The Committee suggests that the Dominions and Dependencies should be communicated with at once, and their views ascertained as to the following proposal made to carry out effectually the conclusions to which the Committee has unanimously agreed, namely that all wolfram ore or other ores containing wolfram, pay a penalty in a form analogous to an export duty on leaving the Empire of £25 per ton.]

As regards tungsten (tungsten powder and ferro-tungsten), the Committee's conclusions are: (1) it is essential that tungsten should be manufactured within the Empire in such quantities that the normal demands should be easily met, and a sufficient supply for export manufactured, so that in case of an abnormal demand for defensive or other purposes, an adequate supply shall be available within the Empire; (2) that the works manufacturing tungsten which have come into existence, either at the request of the Government or otherwise during the war, shall receive subsidies or special consideration as regards Excess Profits Tax in relation to the amount of money they have sunk in the industry, either by way of wolfram ore dressing plant, tungsten producing works, research work, mines or concessions for the raising of wolfram ore, and generally with a view to meeting German competition after the war.

PRUNE CULTIVATION IN FRANCE.

The cultivation of the prune in France is said to have been started at Clairac, in the Department of Lot et Garonne, by monks of that region. The principal varieties now grown, writes the United States Consul at Bordeaux, are the prunes d'Ente, prunes d'Agen, and prunes robe de Sergent. Formerly the prunes du Roi and prunes Saint

Antoine were also cultivated, but these varieties have been largely discontinued because they are more difficult to cook.

For processing, the fruit should be quite ripe before gathering. This fruit, especially the prune d'Ente, is generally found in the best condition for use in September. It seems preferable to let it ripen and fall naturally, as it is then easier to preserve, richer in flavour and colour, and heavier in weight.

If the fruit remains too long on the tree it is shaken down, but to prevent injury straw is spread under the tree, or the ground is softened. The prunes must be picked up promptly, at least once a day under each tree. They are then spread out for a day or two in a dry place, and afterwards placed in ovens to complete the drying. Formerly bakers' ovens were used, but others specially suited to the purpose have now been made. Three periods in the ovens are necessary, the first two to remove all the water in the prune, and the third to cook it. During the first period the temperature must not exceed 45° to 50° C. (113° to 122° F.); during the second period, 65° to 70° C. (149° to 158° F.), and it is said to be very important that the temperature should not exceed the latter mark. After each of these periods the fruit must be exposed to fresh air, and it is necessary to avoid disturbing the fruit while it is warm. The third period, to cook the prune, must have a temperature of 80° to 90°, or even 100° C. (176° to 194°, or even 212° F.). This operation must be conducted carefully to avoid burning the fruit. The length of each period depends upon the condition of the prunes, but is generally about six hours.

The prunes are next separated into eight classes, or grades, depending on the size of the fruit. The class is determined by the number of prunes necessary to make a French pound of 500 grammes (1·1 lb.). Prunes of the superior first grade require but 30 to 35 to the French pound, while there are 40 to 45 of the ordinary first grade; second grade, 50 to 55; third grade, 60 to 65; fourth grade, 70 to 75; fifth grade, 80 to 85; sixth grade, 90 to 95; seventh grade, 100 to 110; and eighth grade, 120 to 125.

The prunes are usually packed in wooden cases of 14 kilogs 200 grammes (31·2 lb.), having a net weight of 12½ kilogs (27½ lb.). For South American trade, cases of 50 kilogs net (110 lb.) are sometimes used, but only for the lower grades of fruit. Decorated tins of half kilog (1·1 lb.) and glass jars are sometimes also used to cater for special demands, but at present special containers are too expensive for profitable use.

OBITUARY.

John Randall Mann, A.M.Inst.C.E.—Mr. John Randall Mann, who has just died in his ninety-first year, was elected a Fellow of the Royal Society of Arts in 1889. He was trained in the offices of the well-known builder, Thomas Cubitt, and when a young man was engaged upon the erection of the front of Buckingham Palace. In 1856 he was appointed surveyor of works on the Osborne estate, Isle of Wight, a position which he held for 35 years.

GENERAL NOTES.

Progress of Irrigation in India.—An interesting and comprehensive review of the progress of irrigation in British India for the year 1916–17 has been issued by the Public Works Department of the Government of India, and affords a very good idea of the past history, present position, and future prospects of irrigation in the Peninsula. The total area irrigated by all the productive public works amounted in the year to slightly more than seventeen million acres. Towards this total the Punjab canals contributed nearly eight million acres, Madras three and a half millions, the United Provinces two and a half millions, and Sind one and a half millions. The return on capital outlay was the highest in Madras, where, excepting two systems, the canals yielded 13·2 per cent. The next province was the Punjab, with a return of 12·99 per cent., while in the United Provinces and Sind percentages of 8·55 and 7·57 were obtained. The mean for the whole of India was 8·81 per cent. Protected works irrigated totalled 385,000 acres, and gave a return of 1·08 per cent., while minor works of all classes irrigated altogether were about eight million acres. Among the large works contemplated are the Sukkur Barrage and the Sind canal system, which is now being investigated by a special staff, the Ghaggar Canal, and the great Sarda scheme in the United Provinces, and also five schemes in the Punjab.—*Board of Trade Journal.*

Coal Outturn.—The annual report of the Acting Chief Inspector of Mines shows that while there were only 2,814 mines at work in Great Britain and Ireland in 1917, against 2,847 in the preceding year, the number of persons employed in and about the mines under the Coal Mines Act increased from 998,063 to 1,021,340. Of these 811,510 worked underground. In and about the mines under the Metalliferous Mines Act, 12,476 persons were employed underground in 1917, and 8,024 above ground, a total of 20,500, compared with 19,455 in the previous year. The number of mines at work decreased from 468 to 452. In and about the quarries 43,631 persons were employed in 1917, against 48,196 in 1916. The output of minerals during the year was 295,401,139½ tons, coal accounting for 248,499,240 tons of the total and iron ore for 14,845,734 tons.

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CONTENTS.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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FRIDAY, OCTOBER 4, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

SCHEME FOR THE PROMOTION OF INDUSTRIAL ART.

In view of the keen commercial competition which will probably ensue between Great Britain and enemy countries at the close of the war, the Council of the Society last autumn considered what steps they should take in order to carry out the object of their charter, "the encouragement of Arts, Manufactures, and Commerce"; and they came to the conclusion that they could not do better than resume their efforts to promote the union of Industry and Art in this country, with the object of improving the artistic and workmanlike qualities of British manufactures, and maintaining for British trade its proper position in the markets of the world.

Accordingly they appointed an Industrial Art Committee, which included, in addition to persons nominated by the Royal Society of Arts, representatives of the Arts and Crafts Exhibition Society, the Design and Industries Association, and the London County Council Consultative Committees on Silversmithing and Allied Trades, Book Production, and Furnishing and Allied Trades.

This committee, after making very careful inquiries among manufacturers, distributors, educational authorities and others, drafted a scheme, of which a copy is appended below. It is believed that it constitutes the first serious attempt to co-ordinate the various movements towards the development and improvement of Industrial Art, and to prevent the overlapping of efforts.

Meantime a scheme for the establishment of a British Institute of Industrial Art was being promoted under the joint auspices of the Board of Trade and the Board of Education, "with the object of raising and maintaining the standard of design and workmanship of works of industrial art produced by British craftsmen and manufacturers, and of stimulating the demand for works of real excellence." The principal feature of this scheme is to be a permanent exhibition in London of modern British works, selected as reaching a high standard of artistic craftsmanship and manufacture.

The Industrial Art Committee have been in conference with the Authorities of the Board of Trade and the Board of Education, and as the two schemes are considered to be mutually complementary, it is intended that they shall work in close co-operation.

The Right Hon. H. A. L. Fisher, M.P., President of the Board of Education, has consented to preside at a meeting to be held at the Royal Society of Arts on Monday, October 28th, at 3 p.m., when the scheme will be submitted for consideration. Amongst those who have consented to speak are Lord Leverhulme, Sir Charles Allom, Sir Woodman Burbidge, Mr. Kenneth Lee, Sir William McCormick, Mr. Gordon Selfridge, and Sir Frank Warner.

As the accommodation is somewhat limited, admission will be by ticket only, and Fellows of the Society who desire to attend the meeting are requested to apply to the Secretary without delay.

THE SCHEME.

I. *Objects.*

1. To encourage and co-ordinate movements towards the development and improvement of Industrial Art, with a view to maintaining for the trade of the British Empire its position in the markets of the world; and especially to stimulate closer mutual understanding and confidence between producers, distributors, educational authorities, societies with similar aims, and individuals interested in these aims.

2. To co-operate with Government Departments and other bodies in promoting exhibitions, and in particular with the Government Scheme for a British Institute of Industrial Art.

[The Exhibitions contemplated would consist of exhibits selected for their artistic and

workmanlike qualities, with the intention of stimulating production, commerce, and public taste.]

3. To initiate and encourage research, experimental and other work germane to the objects above indicated; to award grants for conducting such work; and to co-operate, whenever possible, with Government and other institutions founded for such purposes.

[It is considered highly desirable that researches should be made into a large number of materials in order to ascertain exactly their qualities and the uses for which they are most suitable. The qualities of many kinds of timber, *e.g.*, have not yet been scientifically studied.

The Authorities of the Imperial College of Science and Technology and of the National Physical Laboratory have intimated their willingness to co-operate with the Executive Committee of the Scheme for the promotion of Industrial Art in matters connected with research. With their great staffs of scientific men of the highest distinction, and their admirably equipped laboratories, these institutions offer facilities for work of this kind which are probably unsurpassed in the world.

Another object in view is the award of travelling scholarships to designers, buyers, salesmen, and others, in order to provide them with opportunities of widening their experience and cultivating their taste.]

4. To encourage propaganda work, especially by means of the facilities for lectures and papers afforded by the Royal Society of Arts within the scope of its Royal Charter, "for the encouragement of Arts, Manufactures, and Commerce," and those afforded by other bodies.

5. To raise a central fund to carry out these and such similar objects as may afterwards be determined by an executive committee to be set up at the public meeting to be held in October. The Royal Society of Arts shall be constituted trustee of the central fund.

[Sums given for special purposes by firms, individuals, and societies may bear perpetual designations to associate them with the donors' names, as is the case with other donations and endowments of which the Royal Society of Arts is trustee.

It is suggested that a sub-committee should be set up for each industry which should meet regularly and make recommendations from time to time as to the steps which it is desirable to take in order to promote the interests of that industry. The report of each sub-committee would be submitted to the executive committee, and considered by it both in regard to its general recommendations and to its financial requirements.]

II. *Administration.*

6. The scheme shall be administered by the above-mentioned executive committee, which shall consist of: (1) persons representing contributors to the central fund; (2) members of the Industrial Art Committee of the Royal Society of Arts, and (3) others engaged in work covered by the scheme.

7. Pending the constitution of this executive committee, the Industrial Art Committee shall act for it.

CANTOR LECTURES.

The Cantor Lectures on "The Effect of the War on the Economic Condition of the United Kingdom," by Edgar Crammond, late Secretary of the Liverpool Stock Exchange, and on "High Temperature Processes and Products," by Charles R. Darling, A.R.C.Sc.I., F.I.C., have been reprinted from the *Journal*, and the pamphlets (price 1*s*. 6*d*. each) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. (2)

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

MILITARY EXPLOSIVES OF TO-DAY.

By J. Young, O.B.E., A.R.C.S., F.C.S.,
Chief Instructor in Science, Royal Military Academy, Woolwich.

Lecture I.—Delivered April 8th, 1918.

The subject of explosives is one of the most fascinating branches of chemistry, although studied by comparatively few. Everyone has a general idea of what an explosive is, and yet there is no subject on which the laity are more intensely ignorant, and most seem ready to believe any of the fairy tales of wonderful new explosives which appear at regular intervals.

For instance, early in the war we heard of a French explosive called Terpenite, which killed Germans by the hundred and left them frozen stiff without a mark on them. More recently we heard of an American explosive, of which a thimbleful would lift St. Paul's from its foundations. The chemist who understood explosives did not need even to investigate the stories; he knew that they were mere fiction.

The fact is there have been no epoch-making discoveries in explosives such as, say, the discovery of nitro-glycerine, for many years. None are likely to be made until someone discovers how to dissociate elements into their primitive constituents in a fraction of a second, in the same way as radium does in a million years

or so; and there is little prospect of this at present.

Nitro-glycerine, discovered in 1846, still remains the most powerful explosive in practical use. Many useful advances have been, and are being made, but new explosives are merely new mixtures of old materials, given fancy names. The nations at war use practically the same explosives, and no one can be said to be ahead of the others.

I propose first to deal briefly with the principles governing the subject, since it is by the application of these that any claims for a new explosive must be decided. They were first laid down by the great French chemist Berthelot, in his work "Explosives and their Power" (la Puissance des Substances Explosifs), a work which can still be consulted with advantage by those interested.

Definition.

An explosive is a substance in which a chemical action, once started, proceeds with considerable velocity, and with evolution of heat and gas. It must be self-supporting, and independent of outside agencies.

When the substance is enclosed, the pressure of the gases bursts the envelope, and the shock gives rise to an air wave. We say the substance has "exploded."

The total energy evolved is given out as heat, and may be measured in the bomb calorimeter. But in order to utilise the heat for doing useful work a gas is required. This, by its expansion, propels the shell or bullet, or disrupts the surrounding material.

The power of doing useful work is proportional to the volume of gas per unit weight of the explosive and its temperature. The temperature is not known with any degree of accuracy, but if we assume that the specific heats of the gases evolved by different explosives are the same it will be proportional to the quantity of heat evolved.

Coefficient of potential energy. — The quantity of heat, and volume of gas evolved, can be measured with considerable accuracy in the bomb calorimeter, and the product—

Volume of gas per gram (reduced to N.T.P.) $\times$ calories per gram

is called the coefficient of potential energy, and affords a useful and reliable means of comparing the powers of different explosives, especially those slow in action, such as smokeless powders. Substances like water, which are gaseous at the temperature of the explosion, are reckoned as gases.

The following table gives such a comparison of some of the most typical explosives in use:—

Name of Explosive.	Volume of Gas per gram in c.c. = V.	Calories per gram = Q.	Coefficient = Q × V ÷ 1000.	Coefficient G.P. = 1.	Calculated Temperature $=\frac{Q}{C}$. Assuming C = ·24 C = Specific Heat of Gases.
Gunpowder	280 c.c.	738	207	1	2,240° C.
Nitro-glycerine	741 ,,	1,652	1,224	6	6,880 ,,
Nitro-cellulose (13 per cent. Nitrogen)	923 ,,	931	859	4·3	3,876 ,,
Cordite, Mk. I. (N.G. = 57. N.C. = 38. Vaseline = 5)	871 ,,	1,242	1,082	5·2	5,175 ,,
Cordite M.D. (N.G. = 30. N.C. = 65. Vaseline = 5)	888 ,,	1,031	915	4·4	4,225 ,,
Ballistite (N.G. = 50. N.C. = 50. Stabiliser = ·5)	817 ,,	1,349	1,102	5·3	5,621 ,,
Picric Acid (Lyddite)	877 ,,	810	710	3·4	3,375 ,,

The coefficients correspond fairly well with the results obtained in practical use. The temperatures are certainly too high, as no allowance has been made for the increase in the specific heat of gases at high temperatures, but they are in the correct order. The actual specific heat of gases at such temperatures is not known, and any correction introduced would still leave the matter uncertain.

An experiment quoted by McNab, in which diamonds were found on carbon rods exposed to the flame of exploding cordite, shows that the temperature was certainly above 4000° C.

The table shows that nitro-glycerine is most powerful, and that in mixtures of it with nitro-cellulose the power is proportional to the amount of N.G., which is in accord with practice. Also that the power depends more on the amount of heat evolved than on the volume of gas. Explosives like nitro-cellulose,

which evolve a large volume of gas, are deficient in oxygen, and the gas is mostly CO. In those like nitro-glycerine, where part of the carbon is replaced by oxygen, the gas is CO_2, and the diminution in volume is more than compensated for by the extra heat evolved.

Solid products of combustion are unable to expand and do work, although they absorb their proportion of the heat. They are inactive, and merely produce smoke and fouling. Fifty-seven per cent. of the products of combustion of gunpowder are solids, which explains its weakness and defects.

The temperature of explosion is of great importance in the case of smokeless powders, as it is found that the erosion and consequent wear of a gun increases rapidly with an increase of temperature.

As examples of different kinds of explosives, I first heat some ammonium bichromate in a test tube. At a certain temperature it ignites, and the internal combustion which takes place continues without further application of heat. Large volumes of nitrogen gas and steam are given off, and a residue of chromium oxide, many times bulkier than the original substance, is left.

$$(NH_4)_2Cr_2O_7 = N_2 + 4H_2O + Cr_2O_3 + \text{heat}.$$

It is a true explosive, but a very bad one. It gives little gas (440 c.c. per gram), little heat, and a huge residue.

A little gunpowder, when ignited, flashes off, and besides gas gives a cloud of smoke, due to solid residue.

A piece of cordite burns slowly, gives only a trace of smoke, and leaves no residue.

Some loose guncotton flashes off rapidly, because of its porosity, but leaves no residue or smoke.

Products of combustion.—The products of combustion depend on the pressure under which the explosive burns, except in the case of gunpowder. Smokeless powders, and most modern high explosives, when burnt under atmospheric pressure, give off oxides of nitrogen which are highly poisonous. But under fairly high pressure, as in a gun, the nitrogen comes off as free gas and is harmless.

A simple experiment will show exactly what takes place in a gun when it is fired (Fig. 1).

A tall glass cylinder is filled with water, and a wide glass tube, a little longer than the cylinder, is immersed in it. The tube is fitted with a cork and stopcock, and another cork, smaller in diameter than the tube, so that it can slide easily inside it, is fitted with a piece of glass tube to act as holder for a piece of cordite (about ·5 c.c.). I drop the cork with its piece of cordite into the tube, so that it floats on the water, then ignite the cordite, and quickly insert the upper cork, with stopcock closed. The cordite is seen to burn steadily, giving off gas which drives the cork and water to the bottom of the tube, any excess of gas then escaping.

The tube represents the gun, the cork and water the shell. As the cordite burns the shell moves forward, enlarging the space and preventing any dangerous pressures. In the ideal gun the charge has just finished burning as the shell reaches the muzzle.

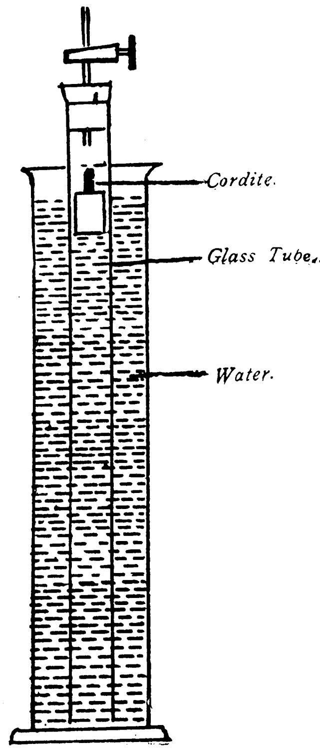

FIG 1.

In the actual gun the rate of combustion of the cordite increases as the pressure rises, but the charge is ignited over the whole of its surface simultaneously, and the total time of combustion is that necessary to burn through half the diameter, or thickness, of a single card or strip.

The gases contain 40 per cent. of CO and 13 per cent of hydrogen, and are inflammable. On opening the tap and applying a light, they are seen to burn. It is these which give the bright muzzle-flash of a gun, and also, some-

times, the back-flash when the breech is opened, which is a source of danger to the gunners.

On raising the tube and allowing air to enter, the gases turn brown, showing that under these conditions they contain nitric oxide (NO).

True explosion is of this kind, and is merely rapid combustion. The substance is ignited at the surface, and burns until the whole is consumed, the time of combustion of a charge varying with the size of the grains, sticks, etc. Detonation is a phenomenon of an entirely different order.

Detonation is the almost instantaneous disruption of a compound or mixture into its elements or simpler compounds, with evolution of heat and gas. Whereas the rate of explosion is measured in centimetres per second, the rate of detonation is from 3,000 to 10,000 metres per second.

Let us consider a 13·5 in. shell filled with lyddite of density 1·6: the velocity of detonation is 7,000 metres per second, the detonator is central, and the detonation has to travel through, roughly, one sixth of a metre. Hence, in $\frac{1}{6} \times \frac{1}{7000} = \frac{1}{42000}$th of a second the whole is converted into gas, occupying $1{\cdot}6 \times 877 = 1{,}242$ times the original volume at 0° C., but at a temperature of 3,375° C. The time occupied in the development of the gas is so short that the shell—or even the atmosphere alone—acts as tamping, and the substance detonates in its own volume, the theoretical pressure developed being 11,500 atmospheres, or 77 tons per square inch. For an instant the shell is intact and filled with gas at this pressure, the next instant it dissolves, and this giant force is applied as a blow to any body in contact with it. Guncotton will cut through its own thickness of iron, and it is probable that lyddite would destroy its own thickness of any material opposed to it, if detonated in intimate contact with it.

Such detonating substances are called *High Explosives*, and their immense shattering effect is due, not only to the volume of gas and quantity of heat, but also to the velocity of detonation and density of the explosive. Shattering power is proportional to

Volume of gas per gram × cals. per gram
× velocity of detonation × density.

The disruptive effect is exerted chiefly in the direction in which the wave of detonation is travelling. In a shell with a central axial detonator it is at right angles to the axis of the shell. This explains some of the apparently erratic effects of high explosive shells.

The effects of high explosive shells are very local, and to obtain full shattering effect it must be detonated in intimate contact with the body to be destroyed. To destroy armour-plate or concrete walls the shell should have a delay-action fuze, so as to allow it time to penetrate. Shells with instantaneous fuzes have been known to fail to damage a tank, because the shell detonated before touching it. On the other hand, we have had examples of German aeroplane bombs with such fuzes, which make no crater, as their main effect is lateral. These are meant for man-killing.

The very intensity of the effect of high-velocity detonating explosives diminishes the radius of their man-killing power, as the metal is blown to dust. A lower-velocity explosive gives larger pieces and projects them further.

Detonating compounds.—In the molecule of a detonating compound each atom is combined with others for which it has little affinity. Take, for example, nitro-glycerine ($C_3H_5(NO_3)_3$). The carbon atoms are combined with hydrogen, for which they have little affinity, and the nitrogen with oxygen and carbon. There is a constant tendency to decompose, and such a compound may be quite stable, while undisturbed, but the moment that the cohesion between the atoms is destroyed in any way it falls into its constituent atoms, which immediately reassemble and combine to form compounds of greatest stability, and give out energy in the process. We say it has *detonated*, and the detonation passes on from particle to particle through the mass.

$$2C_3H_5(NO_3)_3 = 6CO_2 + 5H_2O + 3N_2 + \text{heat}.$$

To start detonation.—Detonation may be started in several ways:—

(1) *By heat.*—For every compound there is a temperature limit at which it decomposes, and if a detonating compound be heated to this temperature it will detonate fully. But in most cases the heating must be very rapid, as most high explosives undergo a lower order of decomposition at a lower temperature, and do not even explode. Nitro-glycerine, rapidly heated, detonates with great violence, but heated a little more slowly decomposes with evolution of red fumes. Picric acid ignites and burns with a smoky flame, but if a little be projected on to a white hot plate it will flash off or even detonate. Similarly with T.N.T and others.

(2) *By shock.*—Any kind of percussive shock, such as a blow on an anvil, will detonate a

high explosive, if sufficiently intense; but a comparatively small shock will suffice *if of the right kind*. It seems as if for each substance a particular kind of vibration was necessary and this is the kind which it gives out itself when detonating. Examples:—

The shock of exploding gunpowder will not detonate guncotton, picric acid, T.N.T., or nitro-glycerine.

The shock of detonating nitro-glycerine will not detonate guncotton.

The shock of detonating guncotton will detonate nitro-glycerine.

Gunpowder is incapable of detonation. Fulminate of mercury will detonate all the above with the exception of T.N.T. cast into slabs, but with the addition of a little lead azide will detonate them fully.

Increasing the quantity of the initiator of detonation above a certain minimum has little effect. One gram of fulminate will detonate an unlimited amount of picric acid. No amount of gunpowder would do it.

A fulminate detonator provides combined shock and sudden heating, and is, therefore, very effective.

The explosive wave. — When a substance detonates, a wave which seems to contain a particular vibration peculiar to each substance is thrown out. This sweeps through the substance, detonating each molecule in turn. It is self-regenerating. This is Abel's theory, and is almost certainly true for pure chemical compounds. Berthelot's theory, that it is merely a wave of pressure which heats the particles which resist it, leaves many phenomena unexplained.

For instance: the more suitable the physical state of the substance for transmitting vibrations the greater the velocity of detonation, and the greater the certainty when once started. It is best when homogeneous and dense, up to a certain point. The velocity of detonation is approximately the same as that of sound in the substance, and sound we know to be a vibration. Gelatinised substances do not transmit vibrations well, and are difficult to detonate.

Liquid nitro-glycerine is easy to detonate, and the wave travels well. Frozen N.G. is crystalline. The separate crystals are more sensitive than the liquid, but they behave erratically, and a portion may be blown away undetonated.

Dry guncotton is porous, and the pores are filled with air. It is comparatively easy to detonate. Wet guncotton is quite incombustible, and difficult to detonate; but once started it detonates with greater velocity than dry, as water transmits vibrations more rapidly than air.

Detonation is more easily started in powder or crystals, probably because there is a less mass to take the initial shock; but the wave travels slowly, and may die out in a loose powder. Advantage is taken of this fact in detonating shells. Detonation is first set up in crystals or pellets, and transmitted to the dense filling.

Mixtures of high explosives which require different waves are always difficult to detonate. The wave which suits one does not suit the other, and may die out before it has gone very far.

The most striking example is cordite. It contains 57 per cent. of N.G. and 38 per cent. of guncotton, both sensitive substances which detonate easily. It is completely gelatinised. It can be detonated by percussion, but only the portion under the hammer; the wave dies out immediately. Even a fulminate detonator will only detonate about 2 lb., however large the charge, the amount being evidently proportional to the initial percussive blow. Two detonators will detonate, roughly, 4 lb.

Amatol, a mixture of T.N.T. and ammonium nitrate, is more difficult to detonate than pure T.N.T.

Another kind of detonation.—In the case of many high explosive mixtures much used at present, it is probable that the detonation is of a different order. The mixture contains at least one detonating constituent, the remainder being combustibles and supporters of combustion of the nature of gunpowder. Fulminate detonators are used. The detonator, besides delivering a shock, sends a wave of intensely heated gas at high velocity into the charge. The detonating constituent detonates, and this, along with the fulminate, sends a wave of hot gas through the mass, which causes the almost instantaneous combustion of the other constituents. For this kind of detonation porosity is an advantage, and also several detonators in a large charge. The charge should also be tamped. Mixtures for mining are always made in this porous form; when they set into a solid block, as sometimes happens, they are insensitive, and should be sent back to be reworked. Such detonation is more of the nature of a rapid explosion than true detonation, and is much slower. The average rate of mixtures in use is 3,000 to 4,000 metres per second.

Sympathetic detonation. — The detonating wave can be transmitted through air, earth, water, or other materials, and detonate charges at a distance, which are said to detonate in sympathy. As might be expected, the greater the facility which the intervening medium offers for the transmission of vibrations, the greater the distance at which charges will detonate in sympathy. This applies only to the true detonating wave.

Examples.—If dry guncotton primers are placed half an inch apart in air, and one detonates, all the others detonate. If they are separated by tin screens the result is the same. If placed in an iron tube, which would confine the wave, they may be five feet apart.

Berthelot states that when 100 gram cartridges of dynamite, 75 per cent. N.G., are placed on firm ground 30 cms. apart, the detonation of one will extend to all the others. If placed on an iron rail, the distance may be increased to 70 cms. He also states that five kilos detonated under water detonated other charges three metres distant, and the distance is proportional to the charge.

From this it is evident that in a shell dump the detonation of one shell would probably detonate all in contact with it, although others a few yards distant would escape. A torpedo may detonate the shells in the magazine of a warship, and a submarine mine may do the same. One submarine mine will detonate all others within a certain radius. Counter-mining depends on this principle.

Very rapid explosion may approach detonation in effects. To show this I ignite a small amount of gunpowder—about 1 c.c. It flashes off quietly. I put the same amount in a copper tube, left open at the upper end, and heat it with a Bunsen burner. By this means the whole reaches the temperature of ignition at the same moment, and when it explodes there is a report like that of a pistol.

A substance may either detonate or merely explode (burn), according to the treatment. For example—

Fulminate of mercury, when unenclosed and ignited, burns with a sudden flash. But when struck on an anvil, detonates with a sharp report.

A spot of nitro-glycerine on a piece of filter paper, when struck on the anvil, detonates violently. But a paper soaked in N.G. burns quietly with a greenish flame.

Picric acid, or T.N.T., as already stated, burns quietly when ignited, but can be detonated by percussion or the shock of a detonator.

Cordite can be detonated by hammering, although the wave does not travel far. When ignited it burns regularly.

But this only applies to small quantities. When large masses are ignited, they burn for a time, but the heat given out is almost certain to raise the temperature locally to the detonating point, and the remainder detonates. Cordite is a possible exception. The great explosions at Halifax and in North-East London are examples.

The qualities which are desirable in an explosive, intended for military use, may be summed up as follows:—

A.—*For use as a propellant in guns and rifles*

(1) It should generate a large volume of gas at a moderately high temperature; that is, be powerful, but not too erosive.

(2) The rate of combustion should be uniform, and adjustable by varying the size of the stick or grain; that is, it must be absolutely non-porous or colloidal.

(3) It must be uniform in quality, so that the shooting will not vary.

(4) It should have a high stability at ordinary atmospheric temperatures.

(5) It should not be liable to detonate by the shock of firing.

Cordite and N.C. powders comply fairly well with the requirements, and similar powders are universally used by civilised nations.

B.—*A high explosive for filling shells*

(1) Should give a large volume of gas at as high a temperature as possible. Incendiary effect is desirable.

(2) Have a high density, so as to get as great a weight as possible in a given volume.

(3) Have a high velocity of detonation, when destruction of material is the object.

(4) Be incapable of detonation by the shock of firing or impact against a target.

(5) Should detonate completely and with certainty when the fuse acts.

Picric acid, T.N.T., and amatol fulfil the requirements fairly well.

C.—*An explosive for military mines*

(1) Should give much gas and heat, with a moderate velocity of detonation, so as to have a great lifting effect.

(2) Should be safe under ordinary shocks, even the impact of a rifle bullet.

(3) Should give no poisonous gases when detonated. Craters may have to be occupied,

and mine galleries entered, shortly after the explosion.

(4) Should be detonated with certainty by a fulminate or similar detonator.

Ammonal, blastine, and several other explosive mixtures comply well with the requirements.

D.—*For hasty demolitions by the Royal Engineers.*

(1) It should be safe under the impact of a rifle bullet.

(2) Should have a high velocity of detonation.

(3) Should detonate completely with a fulminate detonator, and produce intense effects even when untamped.

Slabs of wet guncotton comply best, and have been used for a long time. Slabs of picric acid and T.N.T. are also used. Commercial explosives of all kinds are also used when the conditions are suitable, *i.e.* in back areas.

Materials for explosives.—Before commencing a description of the actual explosives themselves, a few remarks on some of the essential materials required for their manufacture may be of advantage.

Nitrates.—In the days when gunpowder was the only explosive saltpetre (potassium nitrate) was essential for the carrying on of a war. It was mostly imported from tropical countries, where it is most plentiful. During the Napoleonic wars the British command of the seas cut off the French from their overseas supplies, and threatened to stop the war in that way. But the French chemists studied the subject, and developed methods for the artificial production of saltpetre which are worked to this day, although neglected of late years.

At present nitrates, or their equivalent nitric acid, are just as essential as saltpetre was in the old days, as all explosives used in guns or shells are products of nitric acid. If the present war had started ten years earlier the Germans could not possibly have kept up their supply of nitrates. But the process for obtaining nitric acid from the atmosphere by the aid of electricity has now been well worked out. Huge works have been established in Germany, and there is little doubt that most of their supplies have been obtained from this source, and are practically unlimited. The process is being worked now in England.

Chlorates. — Potassium chlorate and ammonium perchlorate are much used. But the materials for the preparation of chlorates—electricity and common salt—are plentiful. Potash salts are almost a monopoly of Germany, but the small amounts necessary are easily obtained. There should be no danger of our running short of chlorates.

Cellulose ($C_6H_{10}O_5$).—This is essential for the manufacture of smokeless powders. Its purest natural form is cotton, and this is always used when available. Some chemists, who should have known better, thought that when the supplies of cotton were cut off the Germans would no longer be able to make nitro-cellulose. But it had been shown long before the war that wood could be made to yield about 40 per cent. of good cellulose, and that from this a stable nitro-cellulose could be made, not quite so good as that from cotton. There is little doubt that at present most of the German nitro-cellulose is made from wood-pulp.

Glycerine ($C_3H_5(OH)_3$).—This is essential for the manufacture of nitro-glycerine, which is a constituent of all powders used for heavy guns. The only source is animal and vegetable fats and oils, and the bitter cry from Germany in the early days of the war about the shortage of food fats meant that they were using their limited supplies for the manufacture of glycerine. Every cordite cartridge requires its own weight of fat for the glycerine alone. This statement will explain many things with regard to butter, margarine, coconut oil, copra, and similar tropical imported products.

Acetone ($(CH_3)_2CO$).—This is a fragrant liquid, boiling at 60° C., which has the property of dissolving both guncotton and nitro-glycerine, and is essential in the manufacture of cordite M.D. It is made by distilling calcium acetate, which is a product of the distillation of wood.

Aluminium, in the form of powder, is much used in explosive mixtures. It is permanent at ordinary atmospheric temperatures, but when oxidised gives out a large amount of heat. Its manufacture depends on having a suitable ore and plenty of electric power. Works have long been established in both Britain and Germany, and many places on the Continent.

Some electric furnace products, such as calcium-silicide, are also used, and various common metals and compounds.

The basic materials for the manufacture of high explosives for use in shells are all products of the distillation of coal, and come from the gasworks. They will be dealt with later. For these we are rather better off than other nations.

Explosive Mixtures.

Explosives may be divided into two main classes—explosive compounds and explosive mixtures.

Explosive compounds are substances of definite chemical composition, such as nitro-cellulose, nitro-glycerine, and fulminate of mercury, and are used in the pure form in only a few cases.

Explosive mixtures are mixtures of some combustible, which may or may not be an explosive in itself, with an oxygen supplier, the latter being usually a nitrate, chlorate, or perchlorate. Other oxidisers are available, and used in a few cases.

A third class might be added, consisting of mixtures of explosive compounds with addition of inert materials. Cordite and blasting gelatine belong to this class.

Nitrate mixtures.—Any one of the nitrates can be used as an oxygen supplier for an explosive mixture. *Potassium nitrate* (KNO_3) is best known and most used. It contains 40 per cent. of its weight of available oxygen, is not at all deliquescent, and mixtures containing it require no special protection from the atmosphere, except in tropical climates.

Sodium nitrate ($NaNO_3$) is a much cheaper salt, and contains 47 per cent. of available oxygen. But it is very deliquescent, and cartridges of explosives containing it must be made moisture-proof. In spite of this defect it is largely used in mining explosives of the cheaper variety.

Ammonium nitrate (NH_4NO_3) contains only 20 per cent. of available oxygen, and is very deliquescent, but otherwise possesses many good qualities. All of its products of explosion are gases, and are available for doing work, unlike the metallic nitrates. It is also an explosive in itself, and can be detonated into nitrogen, oxygen, and steam, with evolution of heat. In its natural form it contains water of crystallisation. This is driven off by heat, and the substance packed in barrels in the form of powder. If this is heated above 32° C. it changes its crystalline form and volume; the small amount of water which it still contains combines with the crystals and acts as a cement, so that the whole sets into a solid block. The same thing occurs with ammonium nitrate explosives, which should be kept below this temperature, as when they set solid they cannot be detonated.

Barium nitrate ($Ba(NO_3)_2$) contains 31 per cent. of available oxygen, and is used in some mixtures. This, and others which give colour to flames, are used in compositions for coloured flares.

Ammonium Nitrate Mixtures.

Ammonal.—One of the best known and most used of the ammonium nitrate mixtures is ammonal, in which use is made of the great heat given out by the oxidation of aluminium. A mixture of Al powder with the theoretical amount of ammonium nitrate for complete oxidation would contain 81·6 per cent. of NH_4NO_3. It would yield 1,578 calories per gram—nearly as much as nitro-glycerine—and 682 c.c. of gas. But such a mixture is difficult to detonate, and charcoal was added to make it more inflammable. One such ammonal made in Austria, and used by Austrians as a shell-filling, has the following composition:—

Ammonium nitrate . . .	81·0
Aluminium powder . .	15·0
Charcoal	4·0

The addition of di-nitro-toluene. or tri-nitro, makes detonation more certain, and the new ammonals contain one or the other. Military ammonal has the following composition:—

Ammonium Nitrate . .	65·0
Tri-nitro-toluene . . .	15·0
Aluminium (coarse powder)	16·0
,, (fine powder) .	1·0
Charcoal	3·0

It is a coarse black powder, very insensitive, and cannot be exploded by the shock of a bullet or application of flame. When heated strongly it inflames and burns. When thrown on a red-hot surface it flashes off. It requires fulminate detonators and strong tamping for best effect. With large charges, several detonators fired simultaneously are advisable. All cartridges must be hermetically sealed to preserve them from moisture, which quickly ruins ammonal. The velocity of detonation is about 4,000 metres per second, and the effect intermediate between that of gunpowder and dynamite. Power, three to four times that of gunpowder.

Enormous quantities of ammonal are now used in military operations. For charging grenades and bombs. For military land mines; some of our biggest and most successful mines were charged with ammonal. It is not now used as a shell filling.

In the charcoal ammonal a portion of the aluminium is fine powder to assist ignition, and the remainder coarse to resist oxidation on keeping.

Sabulite.—This is an explosive resembling ammonal, but calcium silicide, Ca_2Si, an

electric furnace product, takes the place of the aluminium. Its composition is as below:—

Ammonium Nitrate . .	78·0
Tri-nitro-toluene . . .	8·0
Calcium Silicide . . .	14·0

It is a granular, dark greenish-coloured powder. In properties it resembles ammonal, but is more sensitive. It is also used for mines, bombs, and grenades. It is detonated in the same way as ammonal, and has about the same power.

Bellite is one of the earliest ammonium nitrate explosives. It has the composition—

Ammonium Nitrate . .	83·0
Di-nitro-benzene . . .	17·0

It is used to some extent for mines, grenades, and bombs. It is detonated in the same way as ammonal and sabulite, but is less powerful.

Amatol.—This is a mixture of ammonium nitrate and T.N.T. in various proportions, which is now of great importance. T.N.T. does not contain enough oxygen for its complete combustion, and although the addition of ammonium nitrate increases the weight of the charge the increase of the heat given out more than compensates for this. The equation representing complete combustion of the T.N.T. is as follows:—

$$2C_2H_2(NO_2)_3CH_3 + 21NH_4NO_3 = 14CO_2 + 47H_2O + 24N_2$$

2×227 $\qquad$ 21×80

$2 \times 227 = 434$ grams of T.N.T. require $21 \times 80 =$ 1,680 grams of NH_4NO_3 for complete combustion. Such a mixture would contain 78·7 per cent. of NH_4NO_3 and 21·3 per cent. of T.N.T. It would give 1,042 calories and 892 c.c. of gas per gram, with a coefficient of 929, whereas pure T.N.T. gives a maximum of 732 calories and 987 c.c. of gas per gram, with a coefficient of 722. Various mixtures are now in use, the proportion of ammonium nitrate to T.N.T. being given as a fraction. Thus—90/10·80/20·50/50·40/60. Some of these are given fancy names.

The higher the proportion of ammonium nitrate the greater the difficulty of detonation, and the difficulty increases when the ammonal is melted and cast into solid blocks or slabs, as is necessary for shells. Hence the higher proportions are used in the form of powder for bombs, grenades, and mines, and detonated by fulminate detonators. The others, used for shell filling, are detonated by special methods, and will be referred to later.

All varieties of amatol are powerful H.E. The velocity of detonation is about 4,500 metres per second. All are spoiled by moisture, and must be waterproofed. All are practically smokeless. The products of detonation of the mining varieties are CO_2, H_2O, and N_2, and are non-poisonous.

The Germans also use ammonium nitrate explosives. Two used extensively for land mines and mined traps in evacuated territory are *Donarite* and *Westphalite*, both industrial explosives.

A typical Donarite has the composition—

Ammonium Nitrate . .	80·0
Tri-nitro-toluene . . .	12·0
Nitro-glycerine	4·0
Flour	4·0

There are several varieties of Westphalite. One has the composition—

Ammonium Nitrate . .	70·5
Di-nitro-toluene . . .	11·0
Flour	2·0
Sodium Chloride . . .	16·5

The NaCl is to diminish the temperature of explosion so as to make it suitable for coal mines.

These explosives are made into slabs which are wrapped in paraffined paper. Several are packed in a tin case hermetically sealed, and form a cartridge. Holes covered with waterproof paper are left in the tins for the insertion of detonators.

There are scores of similar explosives, and several varieties of each, used for industrial purposes, the weaker and slower varieties being purposely modified for special cases.

All ammonium nitrate explosives must be packed air-tight to prevent entrance of moisture, which quickly ruins them. When heated to a temperature of 32° C. the nitrate changes its crystalline form and increases in volume. This change, aided by the small amount of moisture which is always present, may cause the charge to set into a solid block which is almost impossible to detonate. Hence ammonium nitrate explosives should be kept as cool as possible, and never exposed to direct sun rays.

Other Nitrate Mixtures.

Gunpowder.—For centuries gunpowder was the only explosive, and it is still the best known. It has lost all of its importance as a propellant for use in guns and rifles, yet, owing to the many excellent properties which it possesses, it has at present a greater number of military uses than any other explosive.

Black gunpowder has the following composition:—

Saltpetre, KNO_3	75·0
Sulphur	10·0
Charcoal	15·0

When gunpowder was of the first importance, the charcoal was mostly made from willow, alder, and dogwood, as these were found to be best, but at present birch, poplar, and even common charcoal are found to be good enough for the purposes for which gunpowder is now used. The sulphur and saltpetre must be pure; the charcoal is the only variable constituent.

There is nothing new in the method of manufacture, and no details need be given. The various processes are to ensure (1) thorough incorporation of the ingredients, (2) fairly high and uniform density, (3) uniformity in the size of the grains, these being well polished to give them good keeping qualities. The incorporation used to last from four to eight hours, but has now been considerably shortened for the inferior qualities.

Gunpowder is used extensively as an auxiliary to the more powerful explosives. It is quite permanent when kept dry, but moisture completely spoils it. It has a high ignition point, 300° C., but then ignites readily, and burns quickly and with certainty. It is this certainty of action which recommends it for many purposes. It is comparatively weak, 57 per cent. of the products being solids, mostly K_2CO_3, K_2SO_4, and K_2S_2. These form a smoke cloud, but this is often an advantage for observation purposes.

The following are some of its present-day military uses:—

As igniting primer for smokeless powders.—Cordite and N.C.T. powders do not ignite readily, especially when in thick sticks, and a powerful flash is required. In separate ammunition, where the charge is in a fabric bag, a packet of gunpowder is fixed at one or both ends of the charge. In fixed ammunition for quick-firing guns, a percussion primer is screwed into the cartridge-case. This contains a percussion cap and one to two oz. of gunpowder. The flash from the powder ignites the explosive charge with certainty.

As bursting charge for shrapnel.—A shrapnel shell is filled with bullets, and the head is lightly attached. The bursting charge is only required to blow off the head and liberate the bullets. Little power is necessary, but it must act instantaneously. A charge of gunpowder in a cup at the base of the shell is found to answer best.

As time-fuze composition.—The timing rings in fuzes, which regulate the moment of the burst, are filled with compressed powder. Under atmospheric pressure, this burns with great regularity. Gunpowder is also used for blank charges, for land mines, and has many other minor uses, where certainty of action is of more importance than power.

Picric powder (also called Brugère's powder) is a mixture of finely divided ammonium picrate with potassium nitrate, in the proportions of 43 to 57. It can be detonated by moderate percussion. It is difficult to ignite, but a flame will do it, and it requires good tamping to obtain the full effect. It has about twice the power of gunpowder.

When exploded in a confined space the explosion may proceed to detonation, and the wave set up will extend to picric acid. For this reason picric powder, both in powder form and compressed pellets, is used to detonate lyddite shells.

A less sensitive modification of picric powder, in which the potassium nitrate is replaced by ammonium nitrate, is used for charging bombs, etc.

Tonite.—This is a mixture of about equal weights of barium nitrate and guncotton. It is a powerful high explosive, with great shattering power, and was formerly much used as a blasting powder. It is used in sound-signal rockets.

Smoke compositions.—There are many, some depending on the incomplete combustion of carbonaceous matters. Others consist of nitrates mixed with aluminium or zinc, the oxide of the metal forming a white cloud. Packets are introduced into some high explosive shells to show the position of the burst.

Mixtures of nitrates and chlorates are used in various compositions for flares, and will be referred to later.

INDUSTRIES AFTER THE WAR.

IV.—Textiles.

Of the four Departmental Committees appointed by the Board of Trade to consider the post-war position of our more important national industries, the one which dealt with textiles had probably the most arduous labours; its report certainly is the most extensive of the whole. Upwards of 200 witnesses were orally examined, and nearly as many firms sent written replies to the Committee's *questionnaires*. The trades under consideration

were Cotton, Wool, Silk, Linen, Jute, Lace and Embroidery, Hosiery and Fabric Gloves. The "key" industries, *i.e.* synthetic dyes and knitting needles, for supplies of which, previous to the war, we were entirely or mainly dependent upon foreign countries, also formed part of this very exhaustive inquiry. The Blue-book [Cd. 9070] containing the results of the investigation runs to 130 pages, and is deserving of careful study. The arrangement of the large amount of valuable matter brought together is excellent.

Cotton.

This, perhaps the most powerful of our manufactures and the largest of the world's textile industries, has the lion's share of the report. To assess the exact ratio between cotton production for home use and for export is somewhat difficult, but it is estimated that about 80 per cent. of these fabrics are shipped abroad. The yarn markets are not identical with those for piece-goods. The former fall into two groups—the countries wanting fine counts (spun from raw material of Sea Island, Egypt, Peru, and the West Indies), viz., Germany, the Netherlands, the United States, France, Switzerland, Austria, Italy, Russia and Sweden; and the countries needing the coarser counts (spun from American and Indian cotton)—India, Turkey, the Balkans and South America. Before the war the trade with Germany exceeded all others in importance, and in 1913 was of the value of £5,141,022. The Germans used British fine yarns to make laces, hosiery, fabric gloves, trimmings and velvets for sale in foreign countries, especially Great Britain and the Dominions. Indeed, the outstanding feature of the yarn trade is, or rather was, the extremely large proportion disposed of to enemy countries. This trade, the Committee says, will probably suffer some dislocation after the war, and compensatory markets will have to be secured. At present these are being found in France and neutral countries. In the future the Germans will doubtless increase their fine spinning, so as to be independent of British sources of supply. On the other hand, more lace and hosiery machines and looms are likely to be provided here to manufacture articles previously "made in Germany."

The principal markets for piece-goods are grouped as follows: (*a*) British India and Far East, (*b*) Near East, Egypt, Levant and Balkans, (*c*) Central and South America, (*d*) Continent and United States, (*e*) Africa. The first group absorbs 56 per cent. of the total export, India's share alone being 36 per cent., or roughly £35,000,000 out of £55,000,000. China takes 12 per cent., the Dutch East Indies 4 per cent., the Straits Settlements 2 per cent. and Japan 1 per cent. The respective values of the other groups are—(*b*) £8,417,981, (*c*) £7,899,852, (*d*) £10,400,000. The chief outlets among the Allies in 1913 were: Belgium (£744,801), France (£376,973), Italy (£287,077), Portugal (£125,551), and Russia (£139,813). The report, it should be observed, was written before America entered the war. The value of English piece-goods exported to the United States in 1913 was £1,572,000. Subsequently the prosperity of American and neutral markets caused larger shipments, those to the United States rising to £2,642,592. The increase of exports to the French colonies in Africa has been very marked within the past four years. As supplies from France were not procurable, British goods obtained a footing in markets until then barred by tariffs to our producers. In 1916 the shipments to French Africa realised £6,359,545, of which Morocco's share was £1,178,861.

The Committee views with some concern the part taken by German merchants in the distribution of British textiles in China, and in many other markets prior to the war. Every effort, it is urged, should be made by exporters, either on their own account or in co-operation with merchants on the spot, to secure and retain after the war as great a proportion as possible of the legitimate business formerly handled by German distributing houses. "The present time offers an excellent opportunity. In Hong Kong and Singapore the German houses have been closed and placed in liquidation, and in China and South America they have lost ground considerably. In these circumstances it seems to be desirable that British merchants should either open branches in these markets, or co-operate more closely with existing houses on the spot, or finance young and energetic men with knowledge of the markets and encourage them to open businesses on their own account." The latter proposal seems particularly worthy of consideration as a possible measure of reconstruction. The Committee is informed that the number of British merchant houses which have been established in these markets during the past ten or twelve years is remarkably small.

Examining the vitally-important problem of raw cotton, the Committee shows that throughout the world in recent years there has been a distinct tendency for the demand to exceed the supply; consumption has, in fact, been limited by the available resources, and this state of things, it is believed, will become worse unless special steps are taken to stimulate production. Of a total output of twenty-six million bales the United States in 1912-13 produced fourteen million. Practically none of the Chinese or Russian crop is procurable by the rest of the world. A large proportion of the Indian crop and much of the comparatively small quantities grown in South America and Mexico are also retained for home use. Our dependence upon the United States is all the greater because so much of our spinning machinery is specially adapted to American cotton. About 75 per cent. of the raw material Lancashire consumes comes from the United States. Then, again, American mills are using more and more of the American crop, and the possibility of that crop continuing to expand indefinitely is doubted by many judges.

The report suggests that the British Empire can, and ought to, be made self-sufficing in this matter. Of the possible areas—India, Egypt and the Sudan, the African Colonies and Protectorates —the Committee considers that, for reasons it mentions, India offers the best opportunity for any considerable increase in the near future. Hitherto difficulty has been experienced in securing an adequate price for improved types of Indian cotton owing to the grower not being in direct touch with the world's markets. Better stapled cotton usually gives a smaller yield, is more susceptible to variations in climatic conditions, and requires more care and trouble in cultivation and picking. Naturally the *ryot* is not disposed to grow the better qualities when he is not sure of a better price. Memoranda received by the Committee from the India Office set forth the endeavours of the Supreme and Provincial Governments to improve both the quantity and the quality of the cotton grown. The Committee thinks that an extension of these endeavours might be made with advantage along lines it indicates, but realises that this can hardly be done under the present conditions. In the circumstances it merely recommends that the staff of the Agricultural Department be largely increased throughout the cotton-growing parts, and that some permanent organisation, representing both British and Indian spinners, should co-operate with the Government of India "in securing an adequate price for cotton of improved cleanliness, length, and fineness, until such time as fair and adequate prices can be obtained through the usual commercial channels."

Approximately one-fourth of the British spinning industry relies on Egypt for raw cotton. The Committee considers that the distribution of the Egyptian crop should, during the period of reconstruction, be strictly controlled by the Khedivial Government upon clearly defined lines, so that the requirements of Great Britain and her Allies may be fully safeguarded. In the three years before the war the United Kingdom and her Allies, not including America, received 67 per cent. The proportion of the United States was 11·75. While in Egypt proper, except, perhaps, in the northern part of the Nile Delta, any considerable increase of acreage seems to be doubtful, it is agreed that the Sudan offers a promising field if the various irrigation schemes, postponed on account of the war, are proceeded with. The adoption of a comprehensive plan for the best apportionment of the water available from the Nile is recommended.

With regard to the African Colonies and Protectorates, it is pointed out that though they are well adapted for growing the kind of cotton Lancashire seeks, years of sustained effort must pass before they become a serious factor.

The report strongly urges the immediate appointment of a committee, representing all the interests affected at home and abroad, for the purpose of investigating the question of increasing the Empire's cotton supply. The Committee does not desire that this committee should be invested with any powers of control, and says that in regard to the extent and mode of development the discretion of the various Governments concerned must necessarily remain unfettered.

(*To be continued.*)

TEA INDUSTRY OF FRENCH INDO-CHINA.

A native tea plant (*Thea viridis*), closely related to the Chinese variety, has been cultivated by the natives of Indo-China for many years, and has been exported in considerable quantities since 1900. Europeans have been interested in tea plantations in Tonkin and Central Annam for some time with varying degrees of success, but it is only within quite recent years that native tea has begun to rank among the principal exports of the Saigon district.

The principal tea region of Indo-China is in the province of Quang-Nam, in central Annam. The native village of Tam-ky is the most important tea centre, and most of the exported tea is shipped from Tourane. The provinces of Phu-Tho and Bac-Giang are the chief tea regions of Tonkin. During recent years most of the Tonkin product has been sent to Tourane for preparation. The remainder is exported from Haiphong. An important part of the Tonkin product, consisting of tea flowers formed by the buds, is highly prized by both natives and Europeans. Practically the entire product that is shipped from Tourane goes to France, where it is mixed with Ceylon and other teas. Tonkin tea shipped from Haiphong goes mainly to foreign countries. The exports of native tea from Tonkin and Annam in recent years have been as follows:—

	Tonkin. Kilos.	Annam. Kilos.	Total. Kilos.
1913 . .	79,851	290,062	369,913
1914 . .	121,046	420,173	541,219
1915 . .	67,105	891,164	958,269
1916 . .	106,742	814,507	921,249

In nearly all parts of Indo-China the natives produce tea for their own use, and some tea is sold in the native market for local consumption. The Chinese inhabitants of Cholon, Faifo, and other parts of Indo-China use a little native tea, but its use has not extended in any degree to the European inhabitants. The decline of tea imports since 1914, except probably in Annam, can be fully accounted for by the decrease in the European population since the beginning of the war.

During the past few years tea has become one of the most important articles of export from the Saigon district. The Customs value of the tea exported from Annam during the years 1914-16 was £31,900, £60,200, and £65,400 respectively. The higher value for the 1916 product was due to a change in Customs value corresponding to an improvement in quality. The price of native tea

is keeping pace with the quality, and it is likely, writes the United States Consul at Saigon, that it will hold the rank it has gained among the exports of the district. The fact that Europeans are becoming interested in tea plantations is having a good effect on the methods of cultivation. Another need is an improvement in methods of preparation. The modern installations established by the leading exporters are doing much to remedy these conditions, but it will be some time before all the tea of Indo-China is properly prepared.

The fact that the Annam and Tonkin tea imported into France loses its identity, and is sold under another name, is a misfortune for the local industry. The tea of Indo-China is said to be richer in thein and poorer in tannin than that of India or China. With better methods of preparation being developed, a movement is on foot to launch Annam and Tonkin tea on the French market under its own name. The result is expected to be beneficial.

GENERAL NOTES.

Landing Fields for Aviators in America.—The provision of a chain of landing fields for aviators stretching across the United States is progressing steadily, according to the *Engineer*. In some States landing fields have already been provided, equipped to furnish oil and petrol at intervals of 100 miles. It is planned to have the fields also equipped to furnish shelter, machine shop facilities, maps, charts, and barometer and thermometer ratings to the pilots. Lines of such landing fields have been established in the States of New York, Pennsylvania, Ohio, Illinois, Texas, Georgia, California and others.

South African Timber.—Speaking before the South African Association on the subject of "Timber Supplies and Forestry in the Union," Mr. C. E. Legat, Chief Conservator of Forests for the Union of South Africa, said that in 1913, the last normal year, the importation of timber into the Union amounted to 17½ million cubic feet, worth 1¼ million pounds sterling. Ninety per cent. of the importation was coniferous wood. Though the area of forest reserves in the Union was considerably over 1,000,000 morgen, the area of actual forest was only between 200,000 and 250,000 morgen. This forest produced only one timber, viz., yellow-wood. It was computed that the annual output of yellow-wood would not amount to much more than 1¼ million cubic feet. That amount was only a fraction of the Union's present-day requirements, and in fifty years' time these requirements could be expected to be double, as progress in industry was invariably followed by increased timber consumption. Unless, therefore, South Africa was for ever to remain dependent on other countries for its timber, it was essential that afforestation should be undertaken on a large scale. Neglect of afforestation would result in the Union being forced to compete for the world's surplus timber, and to buy, whatever price might be demanded. Prices were likely to rise steadily, for, in spite of the use of iron, steel, and concrete, the world's consumption of timber was increasing without any corresponding increase of forest. In conclusion it was announced that recently the Government had approved of the initiation of certain schemes which, when ultimately completed, would result in the afforestation of approximately 64,000 acres.

Wood and Peat for Gas-making in Denmark.—The carbonisation of wood and peat for gas-making in Denmark was, says the *Journal für Gasbeleuchtung*, necessitated by the shortage of coal in 1917. Horizontal hand-fired retorts were used; and a certain amount of coal was carbonised, but separately from the substitutes. Trouble occurred owing to accumulations of pitch in the hydraulic main; and on distribution of the gas there was an increase of trouble due to naphthalene stoppages. The yield of ammonia was small; but, the admixture of a proportion of coal-gas sufficed to neutralise the acetic acid present. The air supply of gas appliances required adjustment; but, apart from an increased consumption, the gas behaved satisfactorily in most of its applications. The pitch from wood and peat was valueless; but the brown tar found a ready market. The wood charcoal proved to be well adapted for use in suction-gas producers. Peat charcoal, however, was less satisfactory, as much of it was small, and had to to be employed as an indifferent domestic and industrial fuel.

Shipbuilding in India.—The Indian Munit[illegible] Board announces that in respect of wooden sai[illegible] vessels which may be provided with auxilia[illegible] engines the Government of India will assist constructing firms. An undertaking is given by the British Shipping Controller that in the event of any vessel built in India being required by Government special rates will be paid. The Indian Shipping Controller will help in the way of technical advice and plans, and timber will be supplied by the Madras, Bombay and Bengal Forest Departments at moderate rates and on easy terms of payment, while in Burma the local Deputy Controller of Timber Supplies will assist in negotiations for timber with the firms holding forest leases there. Help will also be afforded in procuring the importation of canvas for sails, as well as other accessories for wooden sailing ships, which it may be necessary to obtain from abroad. Government will ordinarily grant a licence for the flotation of any shipbuilding company which has a fair prospect of being able to commence operations in a reasonable time.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

MILITARY EXPLOSIVES OF TO-DAY.

By J. Young, O.B.E., A.R.C.S., F.C.S.,
Chief Instructor in Science, Royal Military Academy, Woolwich.

Lecture II.—Delivered April 15*th*, 1918.

CHLORATE EXPLOSIVE MIXTURES.

In the first lecture I dealt with the various nitrate mixtures. Next in importance to these are the chlorate mixtures.

Potassium chlorate ($KClO_3$) is a non-deliquescent salt, which, on heating, gives off 39·1 per cent. of its weight of oxygen. It also gives out heat during the decomposition, 1 gram yielding 8·74 calories, and is, therefore, an explosive in itself. It is much used in the preparation of oxygen in laboratories, and if heated too rapidly may explode with great force, as many have found.

When mixed with combustibles it forms explosives much more powerful than nitrate mixtures, but also much more sensitive and dangerous to handle. The discoverer Bertholet, in 1788, tried to use it to replace saltpetre in gunpowder, but at the first attempt the mill promptly blew up and killed some of a company specially invited to see the process.

The sensitiveness may be illustrated by mixing a little powdered chlorate with sulphur; it detonates sharply when struck on an anvil. Similarly with black antimony sulphide, and also with many other combustibles. Chlorate mixtures of this kind are now mostly used for purposes where sensitiveness is a necessity, as in percussion caps, friction igniters, etc.

The mixing of chlorate with combustibles of any kind in the dry state is always dangerous. When done, the substances should be ground separately in clean mortars, and mixed by sifting so as to avoid undue friction.

Potassium perchlorate ($KClO_4$) contains a greater percentage of oxygen, 46·2 per cent., but is a much more stable substance. Heat is absorbed in its decomposition, and mixtures containing it are less sensitive than plain chlorate mixtures.

Ammonium perchlorate (NH_4ClO_4) is still less sensitive, and is now much used in explosive mixtures. With plain combustibles it gives off hydrochloric acid gas when exploded, and as this is very objectionable with mining mixtures a proportion of sodium nitrate is added to convert the HCl into sodium chloride ($NaCl$) which is harmless.

Potassium chlorate and sugar.—Many of the attempts which have been made to reduce the sensitiveness of chlorate mixtures have taken the form of using some imperfect combustible to mix with the chlorate, and sugar has often been proposed. A mixture of two parts of $KClO_3$ with one of sugar is as good as most. It is much less sensitive than a mixture of chlorate with carbon and sulphur, and has about twice the power of gunpowder. But it is still too sensitive and violent in its action. It can be exploded by contact with flame, by moderate percussion on an anvil, and also by contact with strong sulphuric acid. Use has been made of these properties in automatic igniters for other charges. It makes a good flare, but is not a military explosive.

Friction composition.—Many variations are used, but the following gives the proportions of a typical mixture:—

Potassium Chlorate . . .	12
Antimony Sulphide (black) .	12
Sulphur	1

The substances are ground separately, mixed into a paste with spirit containing a little shellac, and formed into pellets, which are dried. Sometimes one part of ground glass is added to make it more sensitive. Sometimes gunpowder is added.

To show its properties apply a flame to a little; it ignites instantly, and the flash is very efficient for igniting other explosives.

Put a little on an anvil and strike sharply. It detonates with moderate percussion.

Put a little on the anvil and rub hard with a hammer face; it explodes sharply.

For many years this has been used in friction tubes for firing heavy guns, and is still used. The friction tube is a copper tube filled with gunpowder which is inserted into the breech of the gun. At the outer end is a cross tube, and in this is a kind of copper rasp or twisted wire. Pellets of the friction composition are pressed closely in contact with the "friction bar," so that when it is pulled out sharply by the gunner the composition explodes and ignites the gunpowder, which sends the flash that ignites the cartridge.

Igniters for safety fuse are made on the same principle. The fuse is tipped with a friction composition which, when rubbed with a prepared surface, flashes off and ignites the fuse.

Equal weights of amorphous phosphorus and chlorate make a most sensitive and powerful explosive, formerly used in an Armstrong shell fuse. They are dangerous to mix dry, but can be mixed safely if moistened with methylated spirit, and then separated into very small portions. The mixture explodes with very gentle percussion or friction. It is used in toy caps.

The use of friction compositions is well illustrated by a box of safety matches. The match head is tipped with friction composition diluted with glue, and can be ignited by strong friction or by percussion. The box is coated with a little amorphous phosphorus and ground glass. A little friction between the two suffices to bring about ignition.

Flash compositions.—A mixture of two parts of potassium chlorate and one part of magnesium or aluminium powder, gives a powerful flash when ignited. The light is very actinic, and suitable for taking photographs. Either mixture can be exploded by percussion, that with aluminium being specially sensitive and powerful, as shown by striking a little on an anvil, and dangerous to handle in quantity.

Mixtures with potassium perchlorate are much safer, and quite effective. One such mixture contains three parts of perchlorate with two parts of magnesium powder. It gives a high temperature, and is used for igniting thermit and other materials in bombs. It also requires careful handling.

Chlorate Mining Explosives.

All of the above-mentioned chlorate explosives are much too sensitive for use in large quantities in military operations. But a discovery made by Street in 1897, that if the chlorate mixture contained oils or fats its sensitiveness was greatly decreased, initiated an entirely new set of blasting explosives. The first, and amongst the best, are the Cheddites, made at Chedde in France. They are mixtures of potassium or sodium chlorate with a nitro compound, and castor oil. A typical cheddite has the composition:—

Potassium Chlorate . . .	79
Di-nitro-toluene	15
Nitro-naphthalene . . .	1
Castor Oil	5

Cheddites are much used as blasting explosives. Potassium perchlorate is used in a number of similar mixtures of which Permonite is an example. Some also contain nitroglycerine.

Blastine.—This is the most important military chlorate explosive, and vast quantities have been used in the present war. There are several varieties, but a typical military blastine has the following composition:—

Ammonium Perchlorate . .	60
Sodium Nitrate	22
Tri-nitro-toluene	11
Paraffin wax	7

It is made in the form of a soft, yellowish, granular substance, which can easily be compressed. It is not very sensitive, but can be detonated by a moderate blow on an anvil. In practical tests, rifle bullets have been fired through cartridges without exploding them, but it can hardly be considered safe under such a test, especially if the cartridge had a hard backing. It ignites easily and burns fiercely with a hot flame. In practice it is detonated by a fulminate detonator, and is a powerful high explosive, about equal to ammonal. Velocity of detonation, over 4,000 metres per second.

Blastine is extensively used for military mines and for charging bombs and grenades. The products of detonation do not contain any hydrochloric acid gas, and are not poisonous.

Permite.—This is a mixture intermediate between ammonal and blastine, and may be looked on as ammonal in which the expensive aluminium is replaced by zinc powder, the consequent diminution in power being compensated for by using ammonium perchlorate instead of the

nitrate. It is made in several varieties. One has the following composition:—

Ammonium Perchlorate . .	82
Zinc Dust	10
Vaseline	5
Asphaltum Varnish . . .	3

Some varieties have sulphur, and methyl alcohol and benzene as solvents.

It is used for the same purposes as blastine, and has about the same power. It is more sensitive to percussion. In form it is a greyish-brown powder.

All of the chlorate explosives require fulminate detonators, and for this reason, besides being too sensitive, are unsuitable for use as a high explosive shell filling. Rate of detonation, 4,000 to 5,000 metres per second.

Mixtures of ammonium perchlorate and paraffin wax with combustibles such as aluminium powder or wood meal are also used, and are powerful high explosives.

Ammonium perchlorate explosives, like the corresponding nitrate mixtures, detonate best when in a porous form. Like these, too, they tend to set into a dense mass when stored, especially if exposed to high atmospheric temperature, and in that condition are very insensitive, and may fail to detonate. They should not be exposed to direct sun rays.

Some Miscellaneous Mixtures.

Thermit, now an important munition of war, is in a class by itself. It is a mixture of about six parts of iron oxide with one part of aluminium powder, highly compressed. It has a very high ignition point, and requires a priming of a mixture of magnesium powder with barium peroxide or potassium perchlorate. When once ignited, a fierce reaction takes place. The aluminium abstracts the oxygen from the iron oxide, liberating metallic iron and so much heat that the temperature is in the neighbourhood of 5,000° C., one of the hottest things on earth. It is used for charging incendiary bombs, and sometimes in a kind of shrapnel. A small explosive charge scatters the contents, which rain down bits of blazing iron, which will instantly set fire to anything capable of burning.

Coloured lights and flares.—These are mixtures of metallic chlorates and nitrates with combustible matter, and sometimes inert metallic salts. Shellac is one of the best combustibles, and sometimes sugar is used. Chlorates make the most energetic mixtures, but 50 per cent. or so of nitrate is usually added to make the mixture slower in action and safer to handle. The colour of the flame depends on the metal used. Thus:—

Barium	compounds	give	green.
Strontium	,,	,,	red.
Copper	,,	,,	blue.
Sodium	,,	,,	yellow, etc.

Many formulæ are in use; the following are examples:—

Green light—	
Barium Chlorate and Nitrate	80 parts.
Shellac (or milk sugar) . .	20 ,,
Red light—	
Strontium Nitrate and Potassium Chlorate	84 parts.
Shellac	16 ,,

Magnesium lights.—Mixtures used for illuminating purposes in rockets or star shells consist of magnesium powder mixed with chlorates and nitrates, a little oil or wax being incorporated to slow the action and make it burn a longer time. 63 parts of a mixture of potassium chlorate and barium nitrate, 35 of magnesium powder, and 2 of boiled linseed oil gives a good lasting light.

The Nitrocelluloses.

As early as 1832 Bracannot discovered that the action of nitric acid on starch and woody fibres converted them into highly inflammable substances. In 1838 Pelouze extended the experiments to paper, linen, and cotton. In 1846 Schönbein, the discoverer of ozone, used concentrated nitric acid and cotton-wool, and called the resulting substance guncotton. A little later, sulphuric acid was added to the nitric, and this mixture has been used ever since.

Schönbein gave demonstrations of the new explosive in England in 1846. The value of an explosive which was several times more powerful than gunpowder, and quite smokeless, was immediately recognised. Its manufacture was started the same year in England at Faversham, and also in France; a little later, in Austria.

Next ensued a series of disastrous explosions which could not be accounted for. The manufacture was stopped everywhere as being too dangerous.

About 1863 the late Sir Frederick Abel conducted a series of experiments at the Waltham Abbey factory, which explained the cause of the explosions, and also how the substance could be made and kept safely. The researches were

published in 1866-67. Briefly, they amounted to this:—

Cotton, in its microscopic structure, is made up of minute capillary tubes. During the process of nitration the tubes become filled with acid, and, as they are practically waterproof, the elimination of the acid by washing is a difficult matter, the amount of washing usually given being quite insufficient. Later, it was shown that some sulphuric acid remains chemically combined with the cellulose.

In stored guncotton both free and combined acids set up a decomposition, with evolution of heat. The rise of temperature accelerates the rate, and when large masses are stored the temperature may at last reach the explosion point, which it did in many cases.

Abel showed that to eliminate the acid a prolonged series of boilings was necessary, these acting, partly mechanically by dissolving the acid, and partly chemically by decomposing the sulphate. Pulping the guncotton, by dividing it into infinitesimal fragments, facilitates the process, besides making it more easily manipulated into suitable forms for use.

The cotton used must be nearly pure cellulose. The natural impurities associated with it, which are of a fatty or resinous nature, form unstable nitro-compounds, which hasten the decomposition of the whole.

Finally, as the guncotton still contains traces of free or combined acid, a preservative capable of combining with the products of decomposition must be incorporated with it. The guncotton will then be fairly stable, but still it has a limited life, the length of which depends on the temperature at which it is stored.

Acting on these principles, Abel established a process for the manufacture of guncotton, which, with some modifications, is carried out to this day. There are other forms of nitrocellulose which, with guncotton, form the most important military explosives of to-day, and are the basis of all smokeless powders.

Cellulose has the empirical formula $C_6H_{10}O_5$, and belongs to the class of bodies called carbohydrates, which includes starch, sugar, and gums. Any one of these will produce an explosive compound when treated with nitric acid. Cotton is the purest natural form of cellulose, and when treated with dilute boiling caustic soda, and chlorine, and afterwards well washed, is almost pure cellulose. Wood and other vegetable fibres contain large percentages of modified celluloses, such as lignose, oxycellulose, pectoses, and so on. As these are more chemically reactive than pure cellulose, they can be removed by reagents, and most of them are removed in the process of preparing wood pulp for papermaking. It has been shown that by a drastic treatment 40 per cent. of good cellulose can be obtained from a suitable wood, and from this a stable nitrocellulose can be obtained, although not quite so powerful as that from cotton. It is extremely probable that most of the German cellulose is now obtained from this source.

Action of nitric acid on cellulose.—When cellulose is acted on by a mixture of nitric and sulphuric acids containing water, either a mono-, di-, or tri-nitrate may be formed, depending on the proportions of the acids and water present. Thus:—

(1)
$$\underset{\text{Cellulose}}{C_6H_{10}O_5} + \underset{\text{Nitric acid}}{3HNO_3} + \underset{\text{Sulphuric}}{nH_2SO_4} = \underset{\text{Tri-nitrate}}{C_6H_7O_2(NO_3)_3} + nH_2SO_4{\cdot}3H_2O.$$

(2)
$$C_6H_{10}O_5 + 2HNO_3 + nH_2SO_4 = \underset{\text{Di-nitrate}}{C_6H_8O_3(NO_3)_2} + nH_2SO_4{\cdot}2H_2O.$$

Similarly, for the mono-nitrate. The H_2SO_4 combines with the water liberated in the reaction, and serves to keep the concentration constant (within limits), but it also probably plays a much more important part.

The actual reactions which take place are certainly much more complicated than as represented, and although much research has been devoted to the problem it is still obscure. Theoretically—

	Per cent.
Tri-nitrocellulose should contain	14·14 of N.
Di- ,, ,, ,,	11·12 ,,
Mono- ,, ,, ,,	6·77 ,,

No one of these has been prepared pure. 13·92 per cent. of nitrogen has been obtained, but the substance was not stable. 13·5 per cent. appears to be the limit for a stable compound, and a good guncotton contains about 13 per cent. of nitrogen. Attempts have been made to account for the varying percentages of nitrogen by multiplying the formula of cellulose and assuming a large number of nitrates, but the results are not satisfactory.

Soluble and insoluble nitrocelluloses.—Some forms of nitrocellulose, especially the greater part of the highly nitrated guncotton, are insoluble in a mixture of alcohol and ether, while other forms are soluble. The lower nitrates are most soluble. It was therefore assumed that the tri-nitrate was the insoluble form, and that the lower nitrates were soluble. As 10-12 per cent. of guncotton was soluble, it

was assumed to be a mixture of insoluble tri-nitro with 10–12 per cent. of di-nitro. As the power of explosion of guncotton depends on the extent of nitration, for this reason, as well as the belief that the soluble variety was unstable, every effort was made to keep down the percentage of solubility.

But we now know that the solubility in alcohol-ether is largely a matter of temperature of nitration. The higher the temperature, up to about 40° C., the greater the solubility. The amount of water present is also a factor. Nitro-cellulose, containing 12·5 per cent. of nitrogen and soluble in alcohol-ether, or at least completely gelatinised by it, is now made on an enormous scale, and constitutes 99·5 per cent. of nitrocellulose smokeless powders, as well as being used in the new cordite.

All kinds of nitrated cotton retain their original structure and appearance, except that they are a little harsher to the touch. They can be spun into yarn or even cloth. When dry, nitrated cotton is very inflammable, and burns rapidly when uncompressed. It can be detonated by percussion, and easily by fulminate.

Manufacture of guncotton.—Practically the only improvement on the original Abel process is the use of the "displacement apparatus" for nitration, instead of the original earthenware pots, where the cotton was allowed to soak in the acid mixture. This was invented by Nathan and Thompson, of Waltham Abbey, and is now generally used.

The figure shows a section of one pan, of which four form a set.

The pan is 3 ft. 6 in. in diameter by 10 in. deep, and is made of earthenware or acid-resisting iron. By means of valves, the outlet can be made to communicate either with an acid supply, a waste acid receptacle, or a drain.

The acid mixture found to be best consists of three parts by weight or ordinary pure concentrated sulphuric acid with one part of nitric. The mixture contains 8 per cent. of water. The details of the process of manufacture are given in any treatise on explosives. The following is an outline of the Waltham Abbey procedure :—

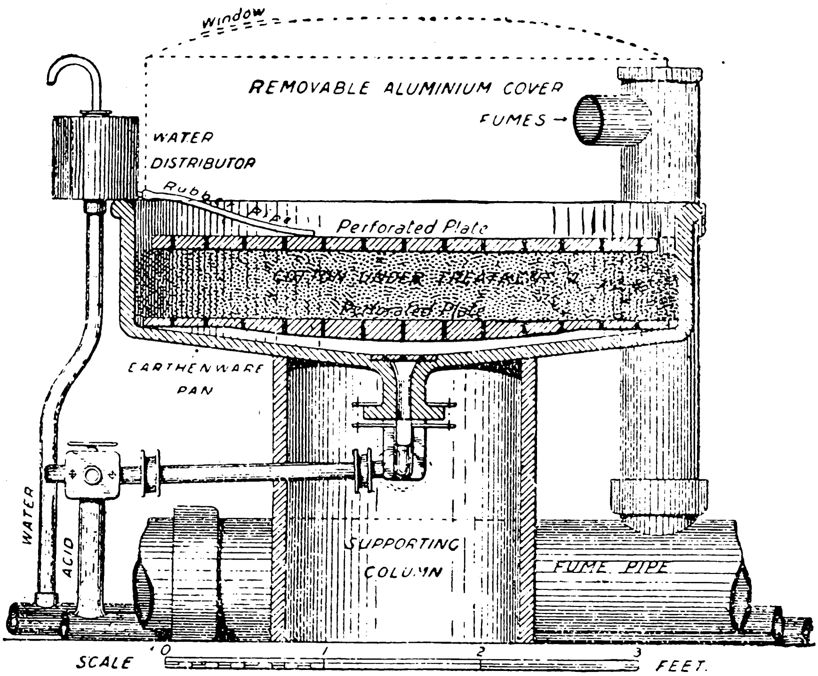

FIG. 2.—GUNCOTTON APPARATUS.—DISPLACEMENT PROCESS.

About 650 lb. of the cooled acid mixture is admitted to the pan, and 20 lb. of the purified and prepared dry cotton immersed. A perforated aluminium plate is then put on top, and water run on to it to act as a seal and prevent the escape of fumes.

After $2\frac{1}{2}$ hours the acid is run off at the bottom slowly, and water run in on top at the same rate, so that the water displaces the acid, thus giving the name to the process. In $3\frac{1}{2}$ hours the nitrated cotton is free from surface

acid, and ready for purification. The advantages over the old process are that it gives a better yield of a more uniform and stable guncotton, besides saving time and labour, and involving less exposure of the workers to acid fumes.

The guncotton is next boiled in great vats which hold nearly a ton of it. There are ten boilings lasting fifty hours, starting with long boilings of twelve hours, and ending with short ones of two hours. It is next pulped in a paper-maker's beater, which cuts it into infinitesimal fragments. The pulp is washed in several changes of water.

When required for the manufacture of cordite, the pure pulp is measured into moulds and subjected to gentle pressure, about 34 lb. per sq. in., which removes much of the water and leaves the guncotton in primers firm enough to be handled. These are taken away to be dried.

When required for use as a demolition agent, a mixture of caustic soda, lime water, and whiting is added to the pulp, sufficient to leave 1 to 2 per cent. in the finished article to act as preservative. The pulp is then moulded and pressed as before, but receives a final pressure of 5 to 6 tons per sq. in., which converts it into slabs. For land service, 15 oz. slabs are the standard, and they are moulded with a central conical hole to take a 1 oz. primer. They are dipped in a solution of carbolic acid and caustic soda to prevent mould, and packed in metal cases which are hermetically sealed. They contain about 17 per cent. of water.

The primers are moulded and pressed in the same way as the slabs, with a central hole to take the detonator. Next, they are dried down to 1 to 2 per cent. of moisture, then dipped in acetone to dissolve the surface and give it a waterproof glaze. They are packed very carefully in special tin tubes, each of which contains one dozen. One ounce primers are the standard for land service. For the naval service slabs and primers of different weights are used.

Slabs of wet guncotton constitute the safest and one of the most effective demolition agents, and remain the standard of the R.E. With more than 13 per cent. of water guncotton is quite incombustible, and very difficult to detonate except by large charges of fulminate, or an ordinary detonator and a dry primer. For example, during the present war an 8-in. shell, detonated in a waggon-load of wet guncotton, failed to explode it. The primers and detonators are carried separately. When detonated in good contact with the object to be demolished it produces intense cutting effect, even untamped, although there is little advantage in increasing the depth of charge above two or three slabs. With large charges tamping is an advantage. A guncotton slab will cut through its own thickness of iron; a necklace of primers tied round a good sized tree will cut it down. The velocity of detonation is about 5,600 metres per second.

As guncotton contains insufficient oxygen for its complete combustion, the gases contain 30 to 45 per cent. of carbon monoxide, and 15 to 20 per cent. of hydrogen. They are both inflammable and poisonous, and for this reason alone guncotton is unsuitable for mining.

In practice the slabs are placed or secured in intimate contact with the object to be demolished, and with one another. A primer is inserted in one slab, and a detonator in the primer. A No. 8 detonator is used when firing is to be done by fuse, safety or instantaneous; a No. 13 electric detonator when the firing is done electrically, which is the best method but takes more time.

The firing of a charge I illustrate by firing a detonator in a safety iron box. Military mines are fired in the same way.

Guncotton was formerly used exclusively for torpedo warheads, marine mines, etc., but has now been largely replaced by T.N.T., and ammonium nitrate and chlorate mixtures.

Guncotton in store.—Like all varieties of nitrocellulose, guncotton decomposes on keeping, and the rate increases with the temperature. Hence it should be kept as cool as possible, and never exposed to the direct rays of the sun. In temperate climates it should be good for twenty years at least, but has a much shorter life in the tropics.

When guncotton shows signs of acidity, or brown fumes are seen, it shows that decomposition has proceeded far, and it is unsafe. When it dries it can be rewetted without any deterioration. It can absorb 30 per cent. of water, but is then too insensitive. In the best condition it should just ooze moisture when pressed by the finger—15 to 17 per cent.

High-nitrated soluble nitrocellulose. — The manufacture of this substance is carried out in much the same way as that of guncotton, the only difference being in the composition of the acid mixture and the temperature of nitration. In one method the acids consist of a mixture of equal volumes of concentrated sulphuric and nitric acid, and the nitration is carried out at 40° C. for half an hour. The product is washed and stabilised as with guncotton, and contains

12·4 per cent. of nitrogen. It is completely gelatinised by an alcohol-ether mixture.

In the manufacture of American nitrocellulose the acids have the following composition:—

Sulphuric Acid	63
Nitric Acid	22
Water	15

The nitration is carried out at 30° to 32° C. in an apparatus similar to that used in the Waltham Abbey plant, and the product is stabilised in much the same way. It contains 12·5 to 12·7 per cent. of nitrogen, and is completely gelatinised by alcohol-ether.

Contrary to former beliefs, this soluble nitrocellulose appears to be as stable as guncotton, but not quite so powerful.

Collodion cotton (also called pyroxylin).—This variety is made by using a still weaker acid mixture, and nitrating at a still higher temperature. In one formula used the acid contains 35·5 per cent. of nitric acid, 44·5 per cent. of sulphuric, and 20 per cent. of water by weight. The nitration takes place at a temperature of 55° C., and lasts half an hour. The product is well washed, but not boiled or pulped.

It contains about 11 per cent. of nitrogen, and dissolves readily in an alcohol-ether mixture (about 1 part in 30 of the mixture by weight) forming a clear solution called collodion. This leaves a perfectly transparent film when poured on a surface and allowed to evaporate. It is much used in photography, and in surgery for covering wounds. Collodion cotton dissolved in camphor forms celluloid. Dissolved in nitroglycerine it forms blasting gelatine, a valuable explosive. Mixed with camphor and castor oil collodion is used for coating incandescent mantles to preserve them during transport.

[NOTE.—A mixture of one vol of alcohol with 2 vols of ether is the best solvent for N.C.]

NITROGLYCERINE EXPLOSIVES.

Nitroglycerine was discovered by Sobrero in 1847, and still remains the most powerful explosive in practical use. It is of great military importance, and is a constituent of our standard smokeless powder.

Glycerine ($C_3H_5(OH)_3$) is a constituent of all animal and vegetable fats and oils, which are the only source of supply on the large scale. The various tropical products, palm oil, coconut oil, etc., are sources of glycerine.

When these fats or oils are boiled with caustic soda or potash (lye), they form a mixture of glycerine and soap, and this is probably one of the oldest chemical processes:—

$$\underset{\text{Mutton fat}}{(C_{18}H_{35}O_2)_3C_3H_5} + 3\,\underset{\text{Soda}}{NaOH} = \underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\text{Soap}}{3C_{18}H_{35}O_2Na}.$$

Pure glycerine suitable for the manufacture of explosives is difficult to separate from the soap, so other processes in which the fats are acted on by high pressure steam, or lime, are used, the products being the free fatty acid or a lime soap, and glycerine. Hence, when fats are scarce and glycerine is required, soap is also likely to be scarce. About 10 lb. of fat are required to produce 1 lb. of glycerine.

When glycerine is required for conversion into nitroglycerine it must have a high degree of purity, and specific gravity not less than 1·26. The acid mixture found best for the nitration contains one part of HNO_3, specific gravity 1·5, and 1·7 parts of H_2SO_4 containing 96 per cent. of pure acid, by weight. When one part of glycerine is poured into eight parts of the acid mixture, previously cooled to a temperature of 15° C., and stirred up with it, the nitrating action takes place immediately. On standing a few minutes the nitroglycerine separates and floats on the acids as a clear liquid. The equation representing the action is:—

$$\underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\text{Nitric acid}}{3HNO_3} = \underset{\text{Nitroglycerine}}{C_3H_5(NO_3)_3} + \underset{\text{Water}}{3H_2O}.$$

The sulphuric acid combines with the water liberated by the reaction, and maintains the concentration of HNO_3. It has no further action.

The nitroglycerine may be separated by pouring the whole mixture into a large volume of water, when the acids dissolve and the nitroglycerine, being insoluble, sinks to the bottom. This is the old method and most suitable on the small scale. On the large scale the nitroglycerine is run off from the top through a suitable opening. The operation is perfectly safe if care be taken not to allow the temperature to rise above about 30° C., which necessitates water-bath cooling. Otherwise a decomposition sets in, indicated by the appearance of brown fumes, and may end in a dangerous explosion.

The nitroglycerine only requires to be washed quite free from every trace of acid, and is ready for use. While in contact with acid, it is dangerously sensitive and unstable.

MANUFACTURE ON THE LARGE SCALE.

Figure 3 represents diagrammatically the arrangement of the apparatus used at Waltham Abbey.

Owing to its dangerously sensitive nature, especially when in contact with acid, the greatest possible precautions are taken in the manufacture of nitroglycerine, and accidents are rare. It is made to flow from point to point by gravity during the operations. The temperature is kept low, and watched carefully by means of thermometers immersed in the liquid. All stirring is done by compressed air issuing from perforated pipes laid round the bottom of the vessels, and during nitration the liquid is kept cool by coils of pipes through which cold water is circulated.

A full description of the process of manufacture can be found in the various text-books; briefly, it is as follows:—

The charge of 4,000 lb. of nitrating acid is admitted to the nitrating vessel, and cooled to 16° C. The charge of 500 lb. of glycerine is then injected in fine spray by means of compressed air, and the acids are kept thoroughly agitated by air bubbling through. The temperature is watched, and not allowed to rise above 22° C. If decomposition sets in, as shown by red fumes and a rise of temperature, the whole charge is shot into a drowning tank filled with water underneath the nitrator. This applies to subsequent operations as well.

When the charge has been nitrated, which takes about forty minutes, it is allowed to stand, and the nitroglycerine separates and floats on the acids. Waste acid from another tank is then admitted to the nitrator to raise the level of the liquid, and the nitroglycerine flows off through a side pipe into the pre-wash tank, which is half filled with water. Here it is washed three times with water, and once with water containing some washing soda. It is then run through a gutter into the washing-house proper, where it is washed three times with warm soda-water, and finally with plain water, which leaves it acid-free and practically pure except for a little water.

The water is skimmed off after each washing, and all stirring is done by compressed air.

Finally, it is filtered through flannel bags filled with dry, common salt, which removes all scum and absorbs moisture. The nitroglycerine is then pure and ready for use.

Properties of nitroglycerine.—Nitroglycerine

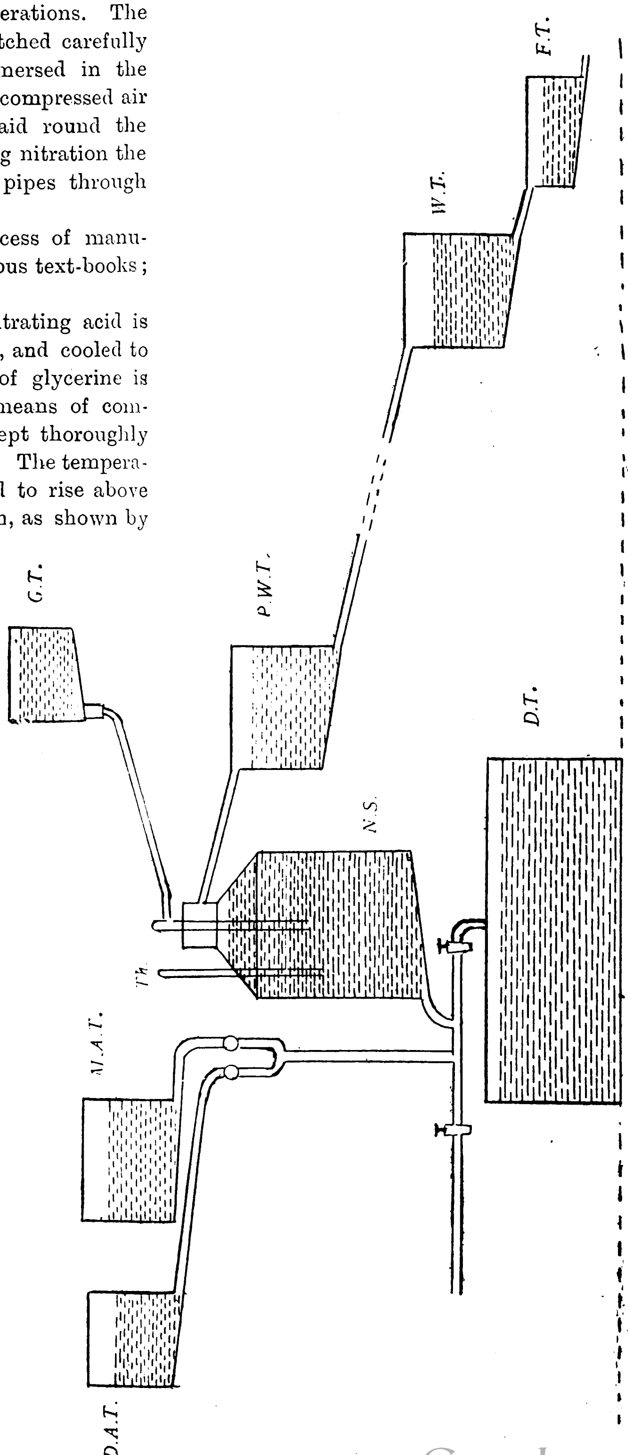

FIG. 3.—NITROGLYCERINE PLANT.—DISPLACEMENT PROCESS.

is a slightly yellowish, transparent liquid, specific gravity 1·6. It is insoluble in water, but dissolves in alcohol, ether, acetone, and many other organic liquids. It is very poisonous, and gives violent headaches even when placed on the skin. It has a powerful action on the heart, and is used as a drug. Many cases of nitroglycerine poisoning occurred in the South African War through soldiers chewing cordite.

The liquid is difficult to ignite, and a taper may be extinguished by dipping it into nitroglycerine; but if a filter paper or some cotton-wool be soaked in the liquid, it burns quietly, but rapidly, with a greenish-edged flame.

To show its explosive properties, put a drop on a filter-paper and strike it with a hammer on an anvil. It detonates with a loud report, and blows the paper to shreds. Put a drop on a smooth metal plate, and heat it fairly rapidly. It gives off vapour at 100° C., boils at about 180° C., but begins to decompose. Red fumes appear, and when the temperature reaches about 180° C. it detonates completely with tremendous effect. When the experiment is successful, a hole is blown in the plate, and the pieces turned right back so as to touch the reverse side.

Fulminate of mercury detonates it completely (about 2 grams will detonate an unlimited amount), with tremendous disruptive effects. A small charge of fulminate sets up an inferior kind of detonation with a velocity of 1,500 to 2,000 metres per second, but with complete detonation the velocity is 7,500 to 8,000 metres per second.

Nitroglycerine is the only explosive compound in use which contains sufficient oxygen for its complete combustion, which explains its great power. The products of detonation contain free oxygen, and are in accordance with the equation:—

$$2C_3H_5(NO_3)_3 = 6CO_2 + 5H_2O + 3N_2 + O + \text{Heat}.$$

It freezes at about 4° C., and forms crystals. In this form it is very sensitive, and merely squeezing crystals between the fingers may explode them; but it does not carry the detonating wave well, and with large charges a great portion may be blown away and escape detonation altogether. This applies to all the nitroglycerine explosives. All require to be thawed before use, which makes them inconvenient for use in cold climates.

Nitroglycerine is the most powerful explosive in use, but in the liquid form is inconvenient and too sensitive to be handled safely. It is now always absorbed in some substance which enables it to be used in a suitable plastic form.

There are two main classes of nitroglycerine explosives in present use.

(1) *The dynamite class.*—The nitroglycerine is absorbed in some porous solid, so that it can be moulded into cartridges. The solid may be an inert substance, or it may be an explosive itself, usually a mixture resembling a primitive gunpowder.

(2) *The blasting gelatine class.*—These have as their basis blasting gelatine, and range from the pure substances to mixtures of mild explosives with varying percentages of it.

Dynamite No. 1, the original dynamite invented by Nobel in 1866, consists of three parts of nitroglycerine absorbed in one part by weight of kieselguhr, a diatomaceous earth. The guhr is calcined and sifted, and is a fine powder free from grit. Up to 2 per cent. of magnesium, sodium, or calcium carbonates are added as preservatives, also ochre to colour it, and sometimes barium sulphate, and similar inert substances. It forms a plastic mass, brown or reddish coloured, and is made into cartridges which are wrapped in parchment paper. It is much less sensitive to percussion than free nitroglycerine, and safer to handle. When ignited in small quantities, it burns fiercely, but does not explode. It is readily detonated by a fulminate detonator, and, as might be expected, its shattering power is about threequarters that of pure nitroglycerine.

Dynamite No. 2 is a mixture of 18 parts nitroglycerine, 71 of potassium nitrate, 10 charcoal, and 1 of paraffin wax.

Lithofracteur contains 50 parts of nitroglycerine and 50 of a mixture of kieselguhr, wood meal, barium nitrate, and a little sulphur.

Carbonite contains 25 parts nitroglycerine and 75 of a mixture of wood meal, potassium and barium nitrates, and a little sodium carbonate.

There are many similar mixtures in use, especially in America. Generally speaking, the smaller the percentage of nitroglycerine the slower they are in action, and hence the greater the rending and lifting, and the less the shattering effect.

All the dynamites are disintegrated by water. They exude their nitroglycerine, which may become dangerous. All freeze at low temperatures, in which state they behave erratically, and are dangerous to handle. They require to be thawed before use, which should be done carefully in the proper apparatus, and not in the rough method of some miners (exposing

cartridges to the heat of a fire), which has led to many fatal accidents.

Blasting gelatine is another valuable explosive invented by Nobel. It consists of 5 to 7 parts of collodion cotton dissolved with the aid of heat in nitroglycerine, with the addition of a little sodium carbonate as preservative. It forms a stiff jelly, which does not exude nitroglycerine in contact with water, and is stored under water. It is made into cartridges like dynamite. It is much less sensitive than pure nitroglycerine, and comparatively safe to handle. It requires a strong detonator, as jellies do not transmit the detonating wave well, and is as powerful as pure nitroglycerine, the excess of oxygen in this substance supplying the deficiency in the collodion cotton. It is the most powerful explosive in use. Rate of detonation, 7,700 metres per second.

There are many mixtures in use containing blasting gelatine as their base, all milder in action, but very powerful.

Gelatine dynamite contains 80 per cent. of blasting gelatine, and 20 per cent. of a mixture of wood meal, potassium nitrate, and guncotton.

Gelignite contains 60 per cent. of blasting gelatine, and the remainder as with gelatine dynamite. It is a very powerful high explosive, with great rending and lifting effect, and much used as a blasting explosive in Britain.

There are numerous other explosives, with fancy names, very similar to the above.

Military uses of nitroglycerine explosives.—Nitroglycerine blasting explosives are not Service explosives, but all military engineers are expected to be familiar with their properties and uses. Large quantities are kept in mining districts, and in war time they are freely used in back areas. They are not suitable for use near the front line, as they are liable to be detonated by a moderate shock, such as the stroke of a bullet.

Cartridges of these explosives make excellent primers for the detonation of large charges of the safety explosive mixtures.

Military Smokeless Powders.

A gunpowder, to be smokeless, must contain no mineral matter which would produce solid products of combustion. This excludes all mineral nitrates, except ammonium nitrate, and attempts to use this as a substitute for saltpetre were defeated owing to its hygroscopic nature.

Before 1860, von Lenk, in Austria, had provided several field batteries with guncotton cartridges. In order to slow its rate of combustion, it was twisted into threads and compressed, but although it then burns slowly under atmospheric pressure, the high pressures in a gun finds out the pores. The flame gases penetrate, the explosion is then so violent that the gun is liable to be destroyed, as was soon found.

In 1875, Shultze powder appeared. It consists of nitrated grains of purified wood, impregnated with nitrates. It was still porous, but the density was so great that the rate of burning was slow enough to make it suitable for shot guns.

It was some time before it was realised that if the rate of combustion was to be under control, the porosity of the substance must be completely destroyed: that no amount of mechanical pressure will do this, and the only way is completely to dissolve it, or at least completely gelatinise it by means of a solvent. When the solvent is evaporated the substance will then be impervious to flame gases at the highest chamber pressures, and burn regularly from the surface only.

The first to realise and make practical use of this fact was Mr. Walter F. Reid, who, with D. Johnston, took out a patent in 1882 for E.C. smokeless powder. This consisted of grains of guncotton impregnated with nitrates, and treated with alcohol-ether. As the guncotton contains a fair amount of soluble nitrocellulose, this was gelatinised and formed an impervious coating and binding for the other portions. The result was a good, almost smokeless powder, which is in use to this day.

With the truly gelatinised explosive, the time of combustion of a charge can be regulated by the diameter of the cord or stick, and so adjusted to the various sizes of guns, or rather to the length of the gun, that the whole charge may be consumed just before the shell emerges from the muzzle. It is also necessary that the rate of production of gas should increase as the shell moves forward in the bore and the space enlarges, so as to maintain the pressure. This is partly brought about by the rate of burning of cordite increasing with the pressure. Take Manse and Petavel's equation, $V = a_0 + ap$, where a_0 is the rate of burning at no pressure, $a = \text{const}\cdot a_0 = \cdot 5$ cm. for cordite and $a = 0\cdot 018$. Therefore in a field gun, where the maximum pressure = 15 tons per sq. in. = 2,240 atmospheres, roughly, the cordite commences burning at the rate of

·5 cm. per second, and at 40 cms. per second at highest pressure.

But the rate of gas production depends also on the surface exposed over which combustion is taking place. With a cylindrical rod the surface diminishes as combustion proceeds. With a flat strip it is practically constant, and the surface is large. With a tube or perforated cylinder it increases as the interior burns away. Hence the various forms—cords, strips, tubes, and flakes, of which specimens are shown.

There are two varieties of smokeless military powders in use at present: (1) *Nitrocellulose powders*, which consist of 99·5 per cent. of gelatinised nitrocellulose, and ·5 per cent. of a preservative; and (2) *Nitroglycerine powders*, which are gelatinised mixtures of nitroglycerine and nitrocellulose, with a few per cent. of a stabiliser.

American nitrocellulose powder (N.C.T.) is typical of the first class. It is made from soluble nitrocellulose containing about 12·5 per cent. of nitrogen. The purified nitrocellulose pulp is freed from water by pumping alcohol through it. Ether is then added to gelatinise it, and ½ per cent. of di-phenylamine to act as stabiliser, and the whole incorporated for about three-quarters of an hour, then pressed until it is a block of stiff colloid. This is pressed by hydraulic pressure through a die arranged to leave one or more perforations, and is cut into short lengths as it issues. For field guns, the rods have one perforation; for larger sizes, they have seven perforations. For a gun such as the 60-pr., the rod is 14 mm. in length and 5 mm. diameter, and has seven perforations. Hence the name N.C.T. It is also made in square flakes.

The greater part of the solvent is afterwards dried out, but from 3 to 6 per cent. remains as a constituent, as without it the powder is too brittle, and the rods are liable to break up and give unduly high pressures.

N.C.T. is a good powder, and fairly stable. It is the weakest of the smokeless powders. Charges must be about 10 per cent. heavier than with cordite to give the same muzzle velocity; but as this is due to the lower temperature of the gases, there is less erosion, and the guns have a longer life. It gives more smoke than cordite, but a less muzzle flash, and there is less danger of a back flash. It is hygroscopic to some extent, and must be protected from atmospheric moisture, as absorption of moisture alters the shooting.

N.C.T. is now much used in our Service for guns and howitzers, the charges being adjusted to give the same muzzle velocity as Cordite M.D.

German nitrocellulose powders are very similar. The rifle powder is made in small flakes which are graphited.

French nitrocellulose powders are different. Poudre B is made from a mixture of guncotton and soluble nitrocellulose. The alcohol-ether used as solvent dissolves the soluble nitrocellulose, and this coats and encloses the insoluble part. It is usually made in strips. It has not so good a history as N.C.T. and cordite. The loss of the "Liberté" in 1911, and the "Jéna," in 1907, was undoubtedly due to spontaneous combustion of poudre B; but this was probably due to other causes than inherent instability.

Russian powders were very similar to American N.C.T., but are of no interest now since the Russians have forgotten their use.

Cordite.

Cordite Mk. I. was for a long time the sole British propellant. It was the result of a series of experiments carried out under the direction of the late Sir Frederick Abel and Sir James Dewar, and its manufacture was commenced in 1889. It was based on Nobel's discovery that when nitrocellulose and nitroglycerine were thoroughly incorporated and gelatinised the sensitiveness of both was diminished, and the resulting substance formed a safe and powerful smokeless powder. Nobel's powder was ballistite, which contained 50 per cent. of collodion cotton dissolved in 50 parts of nitroglycerine, with a small percentage of camphor added as stabiliser. The collodion cotton was objected to as being unstable, and the camphor as volatile. The composition decided on was nitroglycerine 57 parts, guncotton 38, and mineral jelly 5. Acetone was used as the solvent. The mineral jelly (vaseline) was added to modify the violence of the explosion and act as a lubricant for the bore. But later it was found that it was completely burnt up, and also that instead of being a pure paraffin, as supposed, it contained unsaturated hydrocarbons, and was an efficient stabiliser.

Cordite Mk. I. is a very powerful propellant, but owing to the high temperatures produced it is very erosive, and as the result of the South African War a modified cordite, "Cordite M.D.," was introduced. It has the composition—guncotton 65, nitroglycerine 30, mineral jelly 5. Its power is about 10 per cent. less than that of

Mk. I., but the guns last three times as long. Cordite M.D. is the standard British propellant, although others are used at present.

The following is a brief outline of the manufacture.

The guncotton, lightly pressed into cylindrical primers containing 50 per cent. of water, is dried in air at 40° C., until the water is reduced to ½ per cent. It is then weighed into rubber-lined bags and the charge of nitroglycerine poured on. The two are worked by hand into a paste which is quite insensitive compared with either of its constituents. The cordite paste is put into a kneading machine, acetone is added, and incorporated for about three hours. Then the vaseline is added and more acetone, and it undergoes a further incorporation, forming cordite dough. The dough is pressed hydraulically through dies, and issues as cords, strips or tubes. The diameter of the rods and thickness of the tube walls vary from half an inch to one-hundredth of an inch. The acetone is driven off by exposure to warm air, which requires from three to thirty days.

Cordite varies in colour from light yellow to dark brown, according to the vaseline. It is one of the best and most stable of smokeless powders, but like the others is decomposing from the day it is made, and requires care in store and frequent inspection. Different sizes are distinguished by numbers, which give the diameter in hundredths of an inch in the case of sticks, and the outer and inner diameters in the case of tubes. Thus: Cordite M.D. 3¾; Cordite M.D.T. 20–10. For strips the numbers give the width and thickness.

In store cordite should be kept cool and not exposed to the direct rays of the sun. In ships the magazines are artificially cooled. When cooled below about 6° C. the nitroglycerine freezes, and appears as an exudation on thawing. The cordite is said to "sweat." The nitroglycerine is reabsorbed on standing. Sweating cordite should be handled carefully, but may be fired in this condition. Water does not injure it, but it should be dried before use.

There are other modifications of cordite. One is similar to Cordite M.D., except that a mineral jelly containing a larger percentage of unsaturated hydrocarbons is used to increase the stability. In a new modified cordite soluble nitrocellulose is used instead of guncotton, and alcohol-ether is used for the gelatinisation instead of acetone. It contains a larger percentage of nitroglycerine than Cordite M.D., but is very similar, although not quite so powerful.

Ballistite is also used as a military powder. The original ballistite contained 50 parts nitroglycerine and 50 of collodion cotton gelatinised by heat, with the addition of ½ per cent. of diphenylamine as stabiliser. It is rolled into sheets and cut into small square flakes. It is the most powerful of all the smokeless powders, but the most erosive, and only suitable for howitzers where the chamber pressures are low. A modified ballistite has been introduced in which the more stable highly nitrated cellulose is used, and the percentage of nitroglycerine diminished. It has the same characteristics as the other, but is not quite so erosive. The flakes are sometimes graphited. Specimens are shown.

INDUSTRIES AFTER THE WAR.

IV.—Textiles (*continued from p. 717*).

Wool and Woollen Goods.

The British Empire controls nearly 70 per cent. of the exportable surplus of wool for clothing purposes, and between 80 and 90 per cent. of the finer description of this important raw material, viz., merino, large quantities of which, previous to the war, were used by enemy manufacturers as well as by our own mills. The table given on page 731, abridged from one prepared by the Board of Trade Committee, and included in their report, shows the extent of wool production in the year 1915.

In the United States of America, and in the majority of European countries, domestic clips are insufficient for home consumption, and are, or were, supplemented by supplies from the British Empire and the next largest exporter, South America. A serious decrease in the world's wool resources, particularly noticeable in the case of merino, has been experienced during the past few years, mainly owing to a succession of droughts in Australia having caused the number of sheep in the Commonwealth to fall from 93 million head in 1911 to 66 million in 1915; expansion of the frozen meat trade, accentuated by the war; and the breaking up of so much pastoral land in South America, the latter being due partly to the gradual settlement of the Argentine Republic, and partly to the strong demand for wheat in the past four years. Moreover, in Australia cross-breeds are in some degree supplementing merinos. The former mature more rapidly than merinos and are therefore of greater value for mutton. At the Antipodes a special factor is the rabbit pest. It is calculated that the damage these animals do by destroying "feed" is, on the basis of pre-war prices for wool, not less than £5,000,000 per annum. Virtually a British monopoly, upwards of 30 per cent. of merino wool found its way to Germany and Austria, which, without it, would have been unable to turn out, at any rate upon the same scale,

	Total Production.	Merino.	Cross-bred.	Carpet, Wool, etc.
	lbs.	lbs.	lbs.	lbs.
British Empire	1,144,000,000	676,000,000	408,000,000	60,000,000
Allies*	480,000,000	107,550,000	68,450,000	304,000,000
Neutrals	1,108,000,000	278,000,000	492,000,000	338,000,000
Enemy States	67,000,000	13,000,000	54,000,000	——
Total	2,799,000,000	1,074,550,000	1,022,450,000	702,000,000

* United States not included.

the kind of fabrics in which those countries excel. For their purposes South American merino is unsuitable.

After the war there will be an abnormal demand for wool, arising from various causes, *e.g.*, the provision of civilian clothing for the disbanded soldiers; the exceptional requirements of that portion of the non-military population who are buying fewer clothes than in peace times; the re-stocking of devastated districts in Allied countries; our pledges to them, etc. For these and other reasons it appears to the Committee that efficient control of the Imperial supplies will be necessary after the war. Of three measures suggested as a means of effecting this object—export duties, shipment under licence during the period of reconstruction, and State purchase—the Committee favours the second as offering the smallest difficulties. Under such a scheme, it is explained, exports to enemy countries would be prohibited for at least one year after the conclusion of peace or for any longer time considered desirable, and exports to neutral countries restricted to the quality of wool available after the wants of the British Empire and the Allies have been satisfied. If an Imperially co-ordinated policy of licensing "carried out under the direction of small committees of practical men" were to fail, then it appears to the Committee that the only alternative is State purchase. The Committee says that "too much stress cannot be laid upon the fact that this question is essentially one for joint consideration by the Governments of Australia, New Zealand and South Africa in consultation with H.M. Government, and can only be satisfactorily settled by a frank interchange of views and the adoption of a common policy. No effective action is possible without the full co-operation of all the Governments concerned."

As stated above, more than 30 per cent. of the Empire's merino clip in 1913 went to the enemy, but this does not show the full indebtedness of Germany to us. Part of the large exports of this article to France and Belgium was re-exported to Germany in the form of "tops." Of the Empire cross-bred wool Germany and Austria took 12 per cent.

In an exhaustive survey of our woollen and worsted trade, which among textiles is second to the great cotton industry, the Committee reminds us that, though scattered over the whole of the United Kingdom, its principal home is the West Riding of Yorkshire. Of worsted combing and spinning the Bradford district enjoys a practical monopoly, while about half the spindles and almost three-fifths of the looms are also engaged in the largest English county. Eleven years ago the trade produced goods worth about £70,000,000, and gave employment to upwards of 260,000 persons, male and female. In view of subsequent expansion it is estimated that in 1913 about 40 per cent. of the outturn, valued at nearly £38,000,000, was exported. Germany was the most considerable of the markets for semi-manufactured goods. In that year the value of the tops, noils and waste we sold to her was £2,065,922, and of woollen, worsted, mohair and alpaca yarns £4,798,410. Of the woollen piece-goods we exported, our Overseas possessions took 34 per cent., the European Allies 16 per cent., South America 15 per cent., the European enemies 14 per cent., the Far East 8 per cent., European neutrals 7 per cent., and the United States 5 per cent. We imported about ten and a half million pounds' worth of woollen yarns and tissues, 84 per cent. of the former and 71 per cent. coming from Allied countries. Of cloth for men's use and heavier fabrics for women's wear not much reaches us from abroad. Our imports from Germany were mainly yarns, dress stuffs, velvets, and plushes. A large percentage of these goods was made in Alsace and the remainder in Saxony, in both cases apparently from material largely contributed directly or indirectly by the British Empire.

With reference to the outlets for the productions of British top-makers and spinners, attention is drawn to the possibility of expanding specified manufactures at home, and to the extension of business in the markets of the Allies. Temporary dislocation may be caused to certain combing and spinning sections, and the principal aim, the Committee says, should be to replace the German market with home-made goods of a type formerly manufactured in Germany from British tops and yarns. In common with other textile trades, the woollen industry has been handicapped since the war by the scarcity of dye-wares, bleaching powder, sulphuric acid, etc. The majority of the witnesses were in favour of the "immediate adoption of steps which may be considered necessary for the establishment of such subsidiary industries as are essential to the welfare of the main industry, so that we may be independent of foreign and, more particularly, of enemy sources of supply."

The Committee notes that the facilities afforded by the banks appear to be, as a rule, sufficient for

ordinary needs, but recognises that a change in the system of financing some branches of the export trade is necessary to meet and counteract German methods.

It is urged that any duties imposed should be upon a minimum scale in the case of Allied countries, and that every effort should be made to secure mutual tariff concessions, "the general view being that Russia in particular offers favourable opportunities for a considerable extension of British trade if modifications of her tariff in our favour could be brought about."

This section of the report concludes with an interesting account of a highly-specialised branch of the woollen trade, carpet-making, which is in the hands of a comparatively small number of firms having works in Kidderminster, the West Riding and in the West of Scotland, and employing, just before the outbreak of war, some 20,000 hands. One feature of the carpet industry is the tendency to eliminate the middleman as much as possible, in a large number of cases the manufacturer dealing direct with the retailer. It is mentioned that the taste in carpets has changed entirely within the past few years, the present demand being for the seamless woven square rather than for the made-up carpet. This has necessitated the installation of new and more costly machinery.

One point referred to has a bearing on the scheme for the Promotion of Industrial Art to be considered at a meeting of the Royal Society of Arts on Monday, October 28th. The Committee says: "Before the war some difficulty was experienced in securing sufficient designers with original ideas. It is obvious that a great deal of the success in the carpet industry depends on the originality and attractiveness of the designs produced. Before the war, a larger proportion of the designs were of British origin, although a few were purchased in France. To remedy the tendency towards stereotyped designs, it was suggested that more attention should be paid in the technical and art schools to the teaching of design, especially in those centres in which carpets are produced, *e.g.* Halifax, Glasgow, and Kidderminster."

The annual value of the trade is four and a half millions, and approximately a third of the productions are exported, the largest market being British possessions. The value of the carpets and rugs we imported in 1913 was only about £700,000, and the bulk were re-exported. The principal sources of supply were India (£151,606), Turkey (£214,378), and Belgium (£88,900). The carpet industry thinks that there should be a minimum tariff of 20 per cent. *ad valorem* upon goods from Allied countries; a maximum tariff of 30 per cent. *ad valorem* upon goods from neutral countries; and a surtax of 50 per cent. upon all carpets from enemy countries. The Committee simply records these opinions.

(*To be continued.*)

OBITUARY.

Edward Scripps Tudor.—The Society has lost its oldest Fellow by the death of Mr. Edward Scripps Tudor, which took place on September 7th, in his eighty-eighth year. He was elected in 1852, and had thus been a member for sixty-six years.

Mr. Tudor was a well-known merchant in the City, and at one time he was Master of the Haberdashers Company. In addition to his business activities he was deeply interested in charitable and educational work. He founded the hospital at Orford Road, Walthamstow, which, starting as a Cottage Home for Children in 1878, subsequently developed into the present building with fifty beds. He was also a generous supporter of numerous other hospitals, convalescent homes, and charities; and he acted for many years as a trustee of the Forest School for Boys.

GENERAL NOTES.

Paper Driving-belts.—Some particulars of the paper substitute driving-belts, which are now being introduced into German workshops, are given in the *Bulletin des Usines de Guerre*. The paper is cut into narrow bands which are then spun. The belts are made by weaving or braiding. Woven paper belts are of two kinds—paper fabric and paper thread belts, the former being the more frequently used. The fabric is first cut into bands 40 m. long, which are subsequently made up according to the desired width and thickness. A core of strengthening material is interposed, either cotton or sheet metal, though more recently these cores have consisted of paper thread and metal wires interwoven. The core is surrounded with the paper strips and the whole sewn with strong thread. Belts so prepared are said to be very flexible and to wear satisfactorily. Woven paper belts have a tensile strength of from 100 to 125 kilos per centimetre of width.

Adulteration of Saccharine.—According to the *Münchner Neueste Nachrichten*, private trade in saccharine and dulcine is forbidden in Germany by the Saccharine Law of 1902. Recently the surreptitious traffic in these articles has assumed considerable dimensions, and advantage has been taken of this fact to practise fraud. Preparations are frequently offered as saccharine which are not saccharine at all, but consist of carbonate of soda, gypsum, cement, etc., or are adulterated with such ingredients. This pretended saccharine is sold at many times the official price, and generally in original packages which have already been used, or fraudulent imitations of the official packages, or forged Swiss packages. The purchaser runs the risk of suffering considerable injury to health.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

MILITARY EXPLOSIVES OF TO-DAY.

By J. Young, O.B.E., A.R.C.S., F.C.S.,
Chief Instructor in Science, Royal Military Academy, Woolwich.

Lecture III.—Delivered April 22nd, 1918.

High Explosives for Shell Filling.

A high explosive, in order to be suitable for shell filling, must possess special qualities not necessary when it is used for other purposes, even in bombs and torpedoes. *Firstly*, it must have great power, that is give much gas and heat. *Secondly*, it must be insensitive enough to stand the great shock of firing, and even the impact on an armour plate without detonating, so that it may penetrate the latter before the fuse acts. *Thirdly*, it should have a high density, so that a large weight may be enclosed in the limited space, and a high velocity of detonation, so that it may have a great shattering effect. *Finally*, it must detonate completely and with certainty when required, by the action of a detonator which is itself not too sensitive to stand the shock of firing.

These provisos exclude all the nitroglycerine and chlorate explosives, which are too sensitive. Also the ammonium nitrate class, such as ammonal, which are too insensitive, and require a fulminate detonator. Large fulminate detonators in a shell are unsafe, and may lead to premature detonation, although they have been used. The problem of detonating a shell safely and with certainty is the most difficult of all, although it has been solved fairly satisfactorily now. When a shell merely explodes (*i.e.* the filling burns) the action is so slow that the shell breaks up, a large amount of the filling is blown away unburnt, and very feeble effects are produced. Many of the lyddite shells used in the South African War behaved in this way, and except for emitting poisonous vapours did little harm to the enemy.

None of the shell high explosives possess all the desirable qualities. Those now in use have little more than half the shattering power of blasting gelatine. All are products derived from the distillation of coal.

Formerly gunpowder was the only explosive used in shells. Sprengel pointed out in 1871 that picric acid could be detonated, but no attempt was made to use it. A new epoch in shell filling was commenced in 1885 when M. Turpin showed that picric acid, if brought into a dense and homogeneous state, made a safe filling for shells, and could be detonated with tremendous shattering effect. It was adopted by the French under the name of Melinite; later by the British under the name of Lyddite. Other nations also adopted it under various fancy names. Still later tri-nitro-cresol, tri-nitro-toluene, and other aromatic nitrocompounds of a similar nature were introduced, and are now used.

As previously stated, the basic substances required for the manufacture of these explosives are obtained from coal. When coal is distilled in the manufacture of coal gas, about 16 to 20 gallons of tar are obtained from each ton. The tar is a complex mixture, and contains only about ½ lb. of benzene, toluene, and xylene, required by the explosive manufacturer. The coal gas contains about 1 per cent. by volume of the vapours of these substances, equal to about 19 lb. per ton of coal. Formerly this was allowed to remain in the gas, and was the cause of the greater part of its luminosity when burnt in a flat burner. But on the advent of war, and the urgent demand for these hydrocarbons, it was necessary to "strip" the gas, or rob it of these constituents, a process already in use in connection with the gas from coke ovens. The result is that the normal luminosity of coal gas has decreased, but this has not much effect on its heating power and use in

incandescent burners, while 13 to 20 lb. of these mixed hydrocarbons in the form called benzol are now extracted from each ton of coal.

A writer in the *Times* Engineering Supplement states that 40 millions of gallons of benzol can be obtained from the gasworks of Great Britain, in addition to 60 millions already obtained from the coke ovens.

When coal tar is distilled the first portion which comes over at temperatures up to 150° C. is called the "light oil," and is crude benzol, mostly benzene and toluene.

In order to extract the hydrocarbons from coal gas it is submitted to a washing action by a solvent. At first coal tar was used, but the best solvent, and that now generally used, is the "green oil," itself a special high-boiling distillate from the tar. The oil absorbs the benzol, and is afterwards heated and allowed to flow down over a series of superposed cast-iron trays, up through which a jet of steam is passed. The steam vaporises the hydrocarbons, which are carried away and condensed. The oil is returned to the scrubbing plant and can be used over and over again.

The composition of the benzol varies with the quality of the coal used and the process of stripping. It contains 50 to 70 per cent. of benzene, 10 to 40 per cent. of toluene, 1 to 3 per cent. of xylene, and smaller amounts of naphthalene and acids. These substances are afterwards separated by fractional distillation. At present there is a great demand for toluene, but the benzene is also used as a nitro compound in explosives, and in a synthetic process for making phenol.

The next fraction from coal tar distillation—the "middle oil"—contains phenol and other bodies, and the later fractions—the "heavy oils"—also contain valuable compounds.

Phenol (C_6H_5OH), commonly called Carbolic Acid, is obtained from the middle oil of tar distillation. The oil is treated with caustic soda, which dissolves the phenol, cresol, and similar bodies. The solution is removed and treated with sulphuric acid, which precipitates the phenol, etc. The phenol is then separated by distillation. Pure phenol forms a mass of crystals somewhat like sugar in appearance and very different from the crude black liquid called carbolic acid used as a disinfectant. Pure phenol melts at 44° C. and boils at 182° C.

Picric Acid ($C_6H_2(NO_2)_3OH$).—When phenol is added to conc. nitric acid a violent reaction takes place, and the tri-nitro compound is formed—

$$\underset{\text{Phenol}}{C_6H_5(OH)} + \underset{\text{Nitric acid}}{3HNO_3} = \underset{\text{Picric acid}}{C_6H_2(NO_2)_3OH} + 3H_2O.$$

Other reactions take place simultaneously, and resinous compounds are formed. In practice the manufacture takes place in two distinct stages. The methods and proportions of acid used vary considerably. The following method works well:—

First the phenol is mixed with its own weight of conc. sulphuric acid, and heated to over 100° C. for some time. It combines with the acid to form phenol sulphonate ($C_6H_4OHHSO_3$).

The sulphonate is mixed with water and added, a little at a time, to conc. nitric acid. The mixture is kept cool at first, and a di-nitro is formed. Afterwards it is heated by steam for several hours until all oily matters have disappeared, and a clear yellow liquid is formed. This liquid is next allowed to cool, and crystals of picric acid are deposited. The crystals are thoroughly washed with water until free from acid, and wrung as dry as possible in a centrifugal machine. They are afterwards spread on glass tables and dried in air at about 50° C.

Picric acid forms yellow needle-shaped crystals, melting at 122·5° C. when pure. Any impurity lowers the melting-point, so this is the best test for purity. It is slightly soluble in cold water, has an intensely bitter taste, and is poisonous. Its chief use formerly was as a dye for silk and wool.

When heated to about 300° C. it inflames, and burns with a hot flame, and clouds of black smoke containing free carbon. A large mass thus inflamed will burn for a while, but owing to the heat given out will probably end by detonating. A small quantity thrown on a red-hot plate flashes off; when the plate is white-hot it may detonate. It is not very sensitive, and will only just detonate when hammered on an anvil. Half a gram of mercury fulminate will set up the detonating wave, one to two grams will detonate any quantity with certainty, even in its densest form. It can also be detonated by picrates and some other compounds less sensitive than fulminate, and these are used in shells.

Use in shells.—The picric acid is melted in baths heated by oil or hot air and poured into the shell, which is cleaned inside and lined with a non-metallic varnish. A former is placed inside and removed when the acid sets, so as to leave a central cylindrical cavity for the exploder. In this cast form it has a

density of 1·62, and is called Lyddite. It is the most powerful and shattering explosive used in shells. When fully detonated it gives a cloud of black smoke, owing to its deficiency in oxygen, and this is useful for observation purposes, and also for indicating to the gunner that his shells are detonating and producing the desired effect. When the detonator fails, and the shell merely explodes, the action is slow, and much picric acid vapour is blown out, so that the smoke is yellow. The effects are very feeble, although the vapours are poisonous.

The rate of detonation is about 7,700 metres per second.

In spite of its great merits, picric acid has now been largely replaced as a shell filling by tri-nitro-toluene and Amatol, for the following reasons.

Defects of picric acid. — First, the high melting-point prevents the use of low pressure steam as a heating agent, and involves methods which constitute a certain danger. Second, picric acid is a true acid, and when in contact with metals, or metallic compounds such as rust, lime, plaster, lead-paint, etc., forms picrates. All picrates are much more sensitive than the free acid to simple shock; the heavier the metal the more sensitive the picrate, and lead picrate is very sensitive and powerful. If a small amount of one of these was in the shell it might be detonated by the shock of firing, and the detonation would extend to the filling, causing a premature explosion, and the destruction of the gun and detachment.

This may be illustrated by mixing some picric acid with an equal bulk of lead peroxide or red lead, and heating on a tin plate as much as would lie on a sixpence. The mixture detonates with a force only less than that of nitroglycerine and blows a hole in the plate. The mixture also detonates violently by moderate percussion on an anvil.

Hence all operations connected with the preparation of picric acid, the shell filling, and inspection of shells, must be conducted in rooms free from lime or plaster. The shells must be clean and lined with non-metallic varnish. No lead paint is used even on the outside, and no lead alloys in the fuse or anything which would come into contact with the filling.

Given that the picric acid is pure, and proper precautions have been taken, it is quite safe, and the most powerful shell filling in use. It is also unaffected by high atmospheric temperatures, unlike T.N.T., and is specially suitable for tropical climates. The problem of detonating a lyddite shell safely and with certainty is now solved, although this was not the case during the Boer War, or even in the early days of the present war.

Picrates.—When a hot saturated solution of picric acid is mixed with a solution of a metallic salt a picrate is formed, and is easily crystallised out. With potassium carbonate, potassium picrate ($C_6H_2(NO_2)_3OK$) is formed. This, mixed with potassium nitrate, has been used for charging torpedo warheads. With ammonia ammonium picrate is formed ($C_6H_2(NO_2)_3ONH_4$). 43 parts ammonium picrate and 57 parts potassium nitrate form picric powder. It is used as a detonator for lyddite shells.

Tri-nitro-cresol.—Cresol ($C_6H_4OHCH_3$) is a very similar compound to phenol, and also obtained from coal tar. When nitrated in the same way it forms a tri-nitro-cresol ($C_6H(NO_2)_3OHCH_3$). Its properties are very similar to those of picric acid, and it has been used as a shell filling. In Austria it is called Ecrasite; in France, Cresylite. In France it is mixed with picric acid in order to produce a melinite of a lower melting-point.

Tri-nitro-toluene ($C_6H_2(NO_2)_3CH_3$).—Usually called T.N.T., this substance, at present the most important of the shell high explosives, is known in the Service as Trotyl, and is used in other countries under various fancy names, such as Tolite (France), Trilite (Spain), Tritolo (Italy), etc.

It is made by nitrating the hydrocarbon toluene, obtained from the distillation of coal, as previously described. The toluene for this purpose must be pure, clear, and water white. Boiling-point, 110° C. When treated with a mixture of conc. nitric and sulphuric acids it is converted successively into the mono-, di-, and tri-nitro compounds. The following equations represent the successive steps:—

(1) $C_6H_5CH_3 + HNO_3 = C_6H_4NO_2CH_3 + H_2O.$

(2) $C_6H_4NO_2CH_3 + HNO_3 = C_6H_3(NO_2)_2CH_3 + H_2O.$

(3) $C_6H_3(NO_2)_2CH_3 + HNO_3 = C_6H_2(NO_2)_3CH_3 + H_2O.$

The sulphuric acid combines with the water liberated in the reactions.

The complete conversion into the tri-nitro is a long and difficult process, and different methods are used in different works. In some it is done in one operation by the long continued digestion with the mixed acids. In others there are two stages: first a conversion into the

di-nitro, and then by a treatment with fresh acids a conversion into tri-nitro. In others the conversion is done in three stages.

In one method 1 part of toluene is run into 1·7 parts by weight of mixed acids containing 3 parts of sulphuric to 2 parts of nitric. The pan is steam-jacketted, and the result of the reaction is mono-nitro-toluene.

When the reaction is over the acid is run off, and a fresh acid mixture run in and the pan heated. The di-nitro compound is the result of this reaction. The di-nitro-toluene, which is a liquid at this temperature, is run off and allowed to solidify.

The di-nitro is next heated with conc. sulphuric acid until it dissolves, and then run into a pan containing one and a half times its weight of conc. nitric acid, the mixture being kept cool by coils of lead pipe in which cold water is circulated. The mixture is next heated to about 100° C. for several hours, until gas is no longer evolved, being kept well stirred. This action converts most of it into the tri-nitro.

The conversion by a continuous process in one operation has been greatly improved recently, and is now much used.

The acids are then run off, and the still liquid substance well washed with hot water and dilute soda. When it cools it is crude, impure tri-nitro-toluene, and melts at about 70° C.

Purification—The crude T.N.T. made in this way contains impurities, mostly lower nitro-compounds, and isomers of the true T.N.T. The chief of these are oils at the ordinary temperature, and their presence is indicated by a lowering of the melting-point. Pure T.N.T. melts at 81·5° C., but the final purification is so difficult that a product which melts at 80° C. is called "pure."

The chief objection to the presence of these oily impurities is that if the T.N.T. is used as a shell filling, either alone or in one of the higher grades of amatol, the oils have a tendency to separate, and this tendency is increased by a rise in temperature, or pressure in the shell caused by evolution of gas, which sometimes occurs. The oils penetrate porous substances sometimes used to contain the exploders, and creep past the threads of screws. When they enter the gaine exploder and wet the contents, these become insensitive. If the shell is fired in this condition it will fail to detonate, and is a "dud." A new exploder, however, will remedy matters.

Various methods of purification are used. Treatment of the finely-divided substance with hot water in a centrifugal machine has given good results. Washing with cold alcohol is also used, as the impurities are more soluble than the pure T.N.T. For the highest grade of purity the substance is dissolved in hot alcohol and allowed to crystallise out.

Properties. — Pure T.N.T. forms yellow crystals melting at 81·5° C. They are insoluble in water. When heated to about 300° C., T.N.T. ignites and burns with a hot, but very smoky flame. When a large mass is involved the heat given out will invariably raise the temperature to the detonating point. The disasters in East London and at Halifax are examples of this. When fires of this extent are once properly going, it is hopeless to attempt to extinguish them. The most sensible thing to do is to clear the premises and let matters take their inevitable course. T.N.T. is more insensitive than picric acid, and very difficult to detonate by hammering. It is fully detonated by fulminate, except when in the form of cast slabs untamped, when the addition of a little lead azide to the fulminate is necessary. Fulminate detonators are used in bombs, torpedoes, and grenades. T.N.T. can also be detonated by less sensitive substances, such as picric powder and tetryl, and these are used in shells. Its density when melted and cast is 1·55 – 1·6.

T.N.T. is even more deficient in oxygen than picric acid. When fully detonated, the gases liberated consist of CO, H_2, and N_2, and the free carbon liberated forms a thick column of black smoke: hence the name "coal boxes" and "Jack Johnsons." The velocity of detonation in its densest form is about 7,000 metres per second. The power is less than that of picric acid, about in the proportion of 91 : 100. Owing to the inferior velocity of detonation, the shattering effect (brisance) is proportionately still less, about 87 : 100.

Advantages of T.N.T.—The special qualities of T.N.T., which have caused it largely to replace picric acid as an explosive, are as follows:—

(1) Its lower melting-point renders it much safer during the melting and manipulations required in shell filling. (2) It is a neutral substance, and does not form sensitive compounds with metals and their oxides, like picric acid, so no particular care is necessary in cleaning and lining the shells, lead-free paint, etc. Alkalies, however, diminish its stability and render it sensitive, so the shells must not be cleaned with caustic soda. (3) It can be mixed safely with oxidising agents, which is not the case with picric acid. As little as

10 per cent. of T.N.T. mixed with ammonium nitrate gives an explosive as powerful as the pure substance itself. The amatols thus made more than double our resources as regards high explosives.

Only the highest grade of purity is used, as crystals and pellets, in the exploders for high explosive shells. A slightly lower grade is used for filling shells and for making shell amatol. The more impure substance, with a melting-point five or six degrees below normal, is used for making amatols with a high percentage of ammonium nitrate, from which the oils are less likely to separate. This is suitable for mining, bombs, grenades, etc. For shells to be used in the tropics only the purest T.N.T. is suitable.

In shell filling the T.N.T. is melted in steam-heated pans and poured into the shell, where it sets into a yellow crystalline mass. A central cavity is left for the exploder. The detonating arrangements are mentioned later.

Amatol.—Amatol was dealt with in the first lecture. That with the higher proportions of ammonium nitrate, such as 80/20, is more difficult to detonate than when the proportion is lower, and is used in cases where fulminate detonators are used. The mixture most used in shells is 40/60. The mixing and introduction into the shell is done in various ways. Sometimes the T.N.T. is melted and the powdered nitrate stirred in. The plastic, semi-liquid mixture is poured into the shell. Sometimes it is milled cold, the powder introduced into the receptacle and stemmed (compressed), or it is compressed into slabs, which are then packed in. The same exploder is used as with pure T.N.T.

When an amatol shell detonates there is only a little grey smoke, and no definite indication as to whether detonation has been complete or not. For observation purposes a packet of smoke producer is put in. The power is a little greater than that of pure T.N.T., but the velocity of detonation much less—4,000 to 4,500 metres per second, so that the local shattering effect is much less. For some purposes this is even an advantage.

Amatol is the most used of all the shell high explosives at present.

Tetra-nitro-methyl-aniline ($C_6H_2(NO_2)_3NCH_3NO_2$).—This substance is known in the trade as Tetryl, and in the Service as C.E. (composition exploding). It is made by nitrating methyl or di-methyl aniline, substances used on the large scale in the manufacture of aniline dyes. The substance is dissolved in ten times its weight of conc. sulphuric acid, and the solution added slowly to 4½ parts of nitric acid of specific gravity 1·48. The temperature is kept between 44° and 55° C. On cooling, crystals of the substance are deposited, and are washed with water. It is completely purified by crystallising it from its solution in acetone, but inferior grades of purity from nitric acid and boiling water are in use for some purposes.

Properties.—It forms crystals of a fine yellow colour, melting at 129°–130° C. It is more sensitive than picric acid, and can be detonated readily by hammering. When ignited it burns with a very hot smokeless flame, and flashes off when thrown on a red-hot plate. It is readily detonated by a very small charge of fulminate, such as that used in shell detonator caps, is very powerful, and has a velocity of detonation of over 7,000 metres per second. It is an excellent initiator of detonation in other less sensitive explosives.

Uses of Tetryl.—As tetryl (or C.E.) is an excellent initiator of detonation, and has a sensitiveness intermediate between that of fulminate and ordinary shell fillings, it is much used as an intermediary. It is used in the form of powder, grains, and compressed pellets or cylinders up to a few ounces in weight. It is sometimes added to fulminate in ordinary detonators. Compressed cylinders are used in the magazines of some fuses. In powder, pellets, and cylinders it is used in the gaines or detonators for T.N.T. and amatol shells, with which it is very effective.

The Germans also use a compressed cylinder of C.E. as the high explosive charge for some gas shells. The uses of C.E. are extending, although it will probably prove too sensitive, as well as too expensive, for use as a complete shell filling.

Tetra-nitro-aniline ($C_6H(NO_2)_4NH_2$).—This substance is made by the nitration of ordinary aniline. It has great possibilities, although not adopted as a Service explosive. It is a yellowish powder, which cannot be melted without decomposition. When ignited it flashes off without smoke. Its sensitiveness to blows is about the same as that of C.E. It is easily detonated by fulminate, and is said to be as powerful as pure nitroglycerine, if not more so.

It is probably too sensitive to be safe for use as a shell filling, although there seems no reason why it should not be used for other purposes. It is said to have been used in

shells during the present war, but not in our Service.

Hexa-nitro-diphenylamine ($C_6H_2(NO_2)_3)_2NH$).—This is made by nitrating diphenylamine. It is a yellow powder, which does not melt. It is a powerful high explosive, but rather too sensitive for a shell filling. A mixture of this with T.N.T. has been used by the Germans in aerial bombs. They also use it as a high explosive charge in some gas (chemical) grenades.

Tri-nitro-anisol ($C_6H_2(NO_2)_3OCH_3$).—This substance is made by the nitration of anisol, a liquid. Chemically it resembles picric acid. It has been used in shells and bombs.

Nitro-benzenes.—Benzene also gives a series of high explosives. Di-nitro-benzene, readily formed by the action of mixed nitric and sulphuric acids on benzene, is a yellowish solid. It is too deficient in oxygen to be a good explosive in itself, but when mixed with oxidising agents is a powerful explosive. Thus, Bellite and Roburite are mixtures of di-nitro-benzene and ammonium nitrate, the latter having a little nitro-naphthaline added as well. Bellite is used in grenades.

Tri-nitro-benzene ($C_6H_3(NO_2)_3$).—This is also made by the nitration of benzene with mixed nitric and sulphuric acids, but the process is a long one, and full nitration difficult, which has prevented its being used to any great extent. It resembles T.N.T., but is a more powerful explosive.

Methods of Detonation.

Initiators of detonation.—Detonation can be set up in a high explosive charge by simple shock, and this is used in the case of percussion caps, but with large charges a combined shock and intense heat, supplied by some sensitive substance, is most effective in initiating detonation. The nature of the shock is important, and what is best for one high explosive is not necessarily best for another, but in all cases it must be very sharp and sudden, so as to produce momentary intense pressure. Fulminate of mercury is the most generally useful and effective substance for initiating detonation. It is also used in percussion caps for igniting powder charges.

Fulminate of mercury ($C_2N_2O_2H_g$).—It is made by dissolving mercury in nitric acid and acting on the solution with alcohol. Various formulæ are used for its preparation. In one used by Chandelon, which gives good results, one part by weight of mercury is dissolved in ten parts of nitric acid of specific gravity 1·4. When the solution is at 54·5° C. it is poured into ten parts of alcohol of specific gravity ·83. As much as 7 lb. of mercury can be used at one operation. The preparation should be done in the open air, and involves a certain amount of danger.

For preparation on the small scale for experimental purposes, the following I have never known to fail: Dissolve 8 grams of mercury in 70 c.c. of conc. nitric acid of specific gravity 1·45 with the aid of gentle heat. When completely dissolved, and the temperature is not above 40° C., pour into it 90 c.c. of alcohol of specific gravity ·87. All flames near should be extinguished. Next heat the beaker containing the mixture in a hot water bath, until bubbles begin to form and a reaction begins. The reaction is violent, and dense white fumes containing various nitro compounds are given off. When the reaction is nearly over, fill the beaker with water. The fulminate will fall to the bottom. It should be filtered off and washed free from acid. It can be dried quickly by first washing with alcohol until free from water, and then with ether. In a few minutes it will be ready for use.

Fulminate is a crystalline powder, white when pure, but usually grey owing to some free mercury. It is the most sensitive explosive employed practically, detonates easily between iron surfaces, can be detonated between lead and iron, but not between surfaces of wood. It is quite safe to keep when wet. It is usually dried by exposure to warm air (104° F.), and when dry, owing to its sensitiveness, kept in packets of 120 grains as a maximum. When pure it will stand a high pressure, but with the least admixture of grit of any kind a slight pressure will explode it. It is insoluble in cold water, and only slightly so in hot, one part in 130 of water.

When ignited in the open, it burns with a very sudden flash and slight report. But when even slightly enclosed, as in a thin copper tube, and ignited, the first few grains which burn produce sufficient pressure to detonate the remainder. It is this property which makes it of such efficacy in detonating other explosives. Its density is 4·4, and when highly compressed its detonation gives, probably, a higher instantaneous pressure than any other substance in use, except, perhaps, the azides.

Whether exploded or detonated, the products are carbon monoxide, nitrogen, and mercury ($C_2N_2O_2H_g = 2CO + N_2 + H_g + 114{,}000$ cals). If

some fulminate be sprinkled on a clean glass plate and ignited, the mercury is deposited on the plate and forms a mirror, which makes a pretty experiment.

The flash from fulminate is too sudden to ignite gunpowder, which is simply blown away. When required in percussion caps for the ignition of cartridges, it is mixed with potassium chlorate and antimony sulphide. This composition acts more slowly and gives a long, hot flame. Sometimes ground glass is added to increase the sensitiveness to percussion.

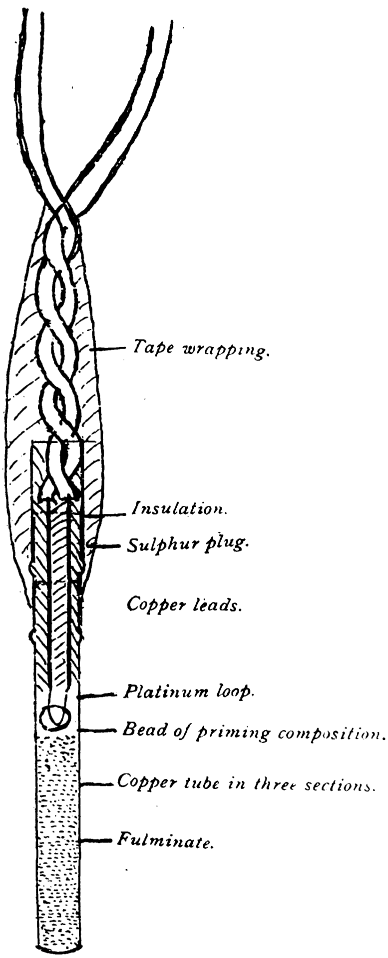

FIG. 4.—ELECTRIC DETONATOR.

The azides, derived from hydrazoic acid (N_3H), are even more effective initiators of detonation than fulminate. Where ·25 gram of fulminate is the minimum which will detonate T.N.T., ·05 gram of lead azide will suffice, and where mercury fulminate alone fails with cast slabs of T.N.T. untamped, an addition of lead azide succeeds perfectly. Lead azide (N_6Pb) is used to some extent at present, either alone or in combination with fulminate. Fulminate, however, is the standard.

The uses of tetryl, picric powder, and some others as initiators of detonation, will be referred to later.

Detonators.—Two varieties are in use, electric and non-electric. Non-electric detonators are thin solid-drawn copper tubes, containing a charge of fulminate. The fulminate is compressed by about 60 kilos on each, which gives it a density of about 2·2. The upper half of the tube is left empty for the insertion of the fuse, safety or instantaneous as the case may be, and is closed by a paper cap until required for use. The detonators are made in various sizes numbered from one to ten, and the numbers are common to all countries. No. 8, most used for military operations, is 55 mm. in length and 6 mm. diameter, and contains two grams of fulminate. No. 5, used for some hand grenades, is 30 mm. long and 6 mm. in diameter, and contains ·8 gram.

Electric detonators are constructed so that they can be fired from a distance by aid of an electric current. The construction varies, but the diagram (Fig. 4) shows the principle.

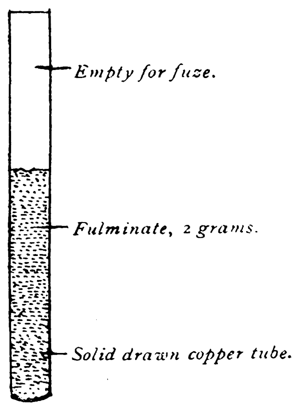

FIG. 5.—NON-ELECTRIC DETONATOR.

The lower part of the tube (which may be solid drawn, or have the end merely sealed with a plug of shellac) contains the fulminate. Copper leads are inserted into the upper end, and these are bridged over by a fine wire of platinum or platinum-iridium alloy. The bridge is wrapped round with fluffy dry guncotton, or imbedded in a bead of priming composition, and the leads are sealed in position with sulphur or other insulator.

When an electric current is passed through it the bridge fuses, ignites the guncotton, and this fires the fulminate. That most used in our land Service has a bridge, quarter-inch long, which requires ·8 ampere to fuse it, and contains forty-three grains of fulminate. The advantages of the electric detonator are many. It can be connected by cables to a point from which it can be fired with perfect safety. When once connected up it can be tested by a small current, and if necessary be left for months, yet be fired at a moment's notice. Also, a number of detonators in charges can be connected to a single firing-point and fired simultaneously. Great use is made of this where a number of land mines have to be fired in one operation. The current is usually supplied by the hand dynamo exploder, where not more than, say, fifteen detonators have to be fired at once. For larger numbers a dynamo, or battery of accumulators is used for certainty.

For hasty demolitions under stress of an enemy advance the ordinary detonator and fuze are used.

Detonation of charges of high explosives.—When the charge to be detonated is not liable to be submitted to any sudden shock, which is the case with land mines, aeroplane and trench mortar bombs, grenades, and even torpedoes—in fact all except shells to be fired from a gun—the problem is simple. The charge is built up in position, the cartridges being packed in their original cases in land mines. In the case of grenades, bombs, etc., a detonator is inserted and a piece of safety fuse inserted in the detonator. With torpedoes a specially large detonator to be fired by percussion is used. Aeroplane bombs are also fired by percussion. For land mines with large charges amounting to tons it is advisable to use several detonators distributed throughout the mass, if this is of one of the slower acting ammonium nitrate explosives, and even primers of blasting gelatine or dynamite may assist. The charge is properly tamped, openings being left for the insertion of the detonators. When fulminate detonators are used in this way failures are very rare.

Detonation of high-explosive shells.—The problem of the detonation of a high-explosive shell is much more difficult. The shell is subjected to an enormous shock in the act of firing, the detonating charge must be in intimate contact with the filling, and if fulminate were used there would be a great risk of this being detonated by the shock. This would detonate the shell in the gun, the gun would be destroyed, and probably the detachment.

On the other hand, when a less sensitive detonating charge is used, which at present means a less efficient one, there is a risk of failure. The shell may merely explode, with very feeble effect. This was frequently the case during the Boer War. The problem seems to have been solved by the introduction of the gaine method.

The Gaine.—The gaine is a metal tube screwed to the fuze which enters a cavity in the filling and makes good contact with it. This is very necessary. It contains a chain of substances, about four, of decreasing order of

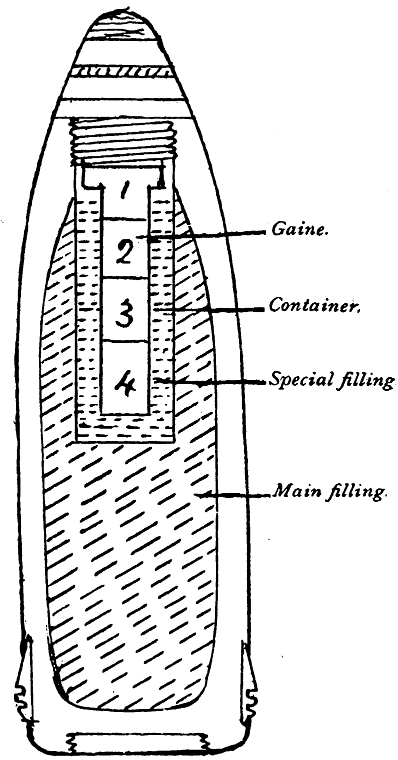

Fig. 6.—High Explosive Shell with Gaine.

sensitiveness starting from the fuse, and increasing order of violence of explosion. Use is made of the fact that a substance in powder is more easily detonated than when in compressed pellets, and pellets than a cast, dense solid. The actual substances vary with the shell and nature of the filling, but always start with gunpowder, which is very certain in action. Thus we may suppose the chain to consist of (1) gunpowder, (2) tetryl powder, (3) tetryl pellets, (4) T.N.T. pellets.

The action is started by a fulminate cap in the fuse, which fires the gunpowder. This

partially explodes and partially detonates No 2, which detonates No. 3, which in turn detonates No. 4, and this detonates the main filling. With fuse and gaine in good condition there are very few failures now.

The detonation of large shells is a simpler matter, as the walls are thicker and provide more efficient tamping. These are still often detonated by a single exploder charge of picric powder (for lyddite) in a recess in the filling.

Figure 6 shows diagrammatically the arrangement of a shell with a gaine detonator. No details of construction are given.

Tests for Explosives.

A large number of tests are applied to explosives for commercial use. Only an outline of those most important from the military standpoint can be given here.

(1) *Sensitiveness to shocks.* — This is important with regard to explosives which have to be handled within reach of enemy bullets. It is usually tested by a *falling-weight apparatus.* About one-tenth of a gram of the explosive is placed on a small anvil, and a hard steel rod placed on top. A weight controlled by guide rods is allowed to fall on the rod, and the minimum height required to explode the charge is a measure of its sensitiveness.

According to this test the chief military explosives can be arranged in the following order of sensitiveness :—

Mercury fulminate.
Nitroglycerine (liquid).
Lead, copper, and iron picrates.
Dynamite No. 1.
Blasting gelatine.
Dry guncotton.
Smokeless powders (vary).
Chlorate explosives (mining).
Tetryl (C.E.).
Picric acid.
Tri-nitro-toluene.
Ammonium picrate.
Wet guncotton.
Gunpowder.
Ammonium nitrate explosives.

(2) *Brisance* (local shattering effect). — For this test a cartridge of the explosive is placed on top of a steel piston, which rests on a copper cylinder placed on an anvil. The cartridge is detonated from the top by a standard detonator, and the shortening of the cylinder is a measure of the brisance. The military engineer has his own special tests, such as finding what weight of the explosive will cut a standard steel rail, untamped.

As previously explained, the shattering effect is proportional to " volume of gas × heat × velocity of detonation density." The following gives the order for the most important explosives :—

Blasting gelatine.
Dynamite No. 1.
Picric acid.
Tri-nitro-toluene.
Guncotton.
Mercury fulminate.
Chlorate explosives.
Gunpowder.

(3) *Power.*—As previously explained, the powers of different explosives can be compared by exploding a weighed charge of each in a modified bomb calorimeter, and measuring the volume of gas produced and quantity of heat evolved. The results are quite reliable. The best practical direct method of comparing powers is the " Trauzl lead-block test."

Trauzl lead-block test.—A cylinder of lead 200 mm. in height and diameter has a hole 25 mm. diameter and 125 mm. deep bored in it. A charge of 10 grams of the explosive to be tested is put in, and a detonator inserted. The charge is tamped by sand and detonated. The increased volume of the hole is afterwards measured, and is proportional to the power of the explosive. The results are in fair agreement with the bomb calorimeter method. Results are, however, really only comparable with explosives which have approximately the same rate of detonation, and discrepancies are explained in this way.

(4) *Test for stability.*—This is a very important test. All explosives of the organic nitrate class, such as nitroglycerine, nitrocellulose, and mixtures containing them, which include all the smokeless powders, are decomposing from the day they are made. The decomposition proceeds at an accelerated rate, and when it has proceeded to a certain point the heat given out may lead to a disastrous explosion where the explosive is stored in large quantities. This has frequently happened.

Several tests have been devised, some very elaborate, but that most generally useful is the original Abel's heat test. It is applicable to all explosives of the organic nitrate class, but not to aromatic compounds such as T.N.T., picric acid, etc. It depends on the following established facts.

(*a*) During decomposition these organic nitrates give off nitrogen peroxide (NO_2); and

a piece of paper treated with potassium iodide and starch is an extremely delicate test for NO_2, which stains it brown or blue.

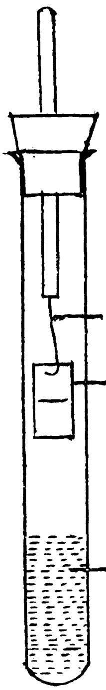

FIG. 7.—ABEL'S HEAT TEST.

(b) An increase of temperature accelerates the rate of decomposition. Roughly, guncotton decomposes as much in one minute at 77° C., as in two years in a store at, say, 15° C.

A standardised apparatus is used for the test, which must be carried out in a specified manner, if results by different operators are to be comparable. Briefly, it is done as follows :—

A small quantity of the finely-divided explosive (1·6 grams for cordite, 1·3 grams for guncotton) is put into a test tube fitted with a rubber cork, through which passes a glass rod ending in a platinum wire with a hook at the end. A piece of the test paper, with its lower half moistened with dilute glycerine, is suspended from the hook so as to hang a short distance above the explosive. The tube is immersed in a water bath kept at a constant temperature (82·2° C. for cordite, 76·6° C. for guncotton), and the time necessary to produce a brown line on the paper is noted, and is a measure of the stability. This must be at least ten minutes for guncotton and thirty minutes for new cordite. Decomposition is so rapid in hot climates, that five minutes will pass a cordite in India.

Figure 7 shows the appearance of the test tube when ready for the test.

RATE OF DETONATION.

This is very important in the case of high explosives, but the apparatus is too elaborate to be described here. Dautriche's comparison method, in which the rate of detonation of a cartridge of the explosive is compared with that of a measured length of detonating fuse filled with T.N.T. having a rate of 6,000 metres per second, is most useful. It will be found described in late standard test-books, such as Marshall's " Explosives."

CONCLUDING REMARKS.

From the foregoing it will be seen that, although enormous work and research is being done, and new mixtures and modifications of old ones are making their appearance every day, there have been no startling discoveries in explosives during recent years. Practically the same explosives are being used by the different nations at war, and none can claim any advantage in that respect.

Also, there does not appear to be much prospect of obtaining more powerful propellants while proceeding on the present lines, as power depends more on heat than on gas, and high temperatures produce excessive erosion of the rifling. With regard to high explosives for shell filling there is still a wide margin, as T.N.T. has only about half the shattering power of blasting gelatine. It should be possible to find some compound equal in power to the latter, and sufficiently insensitive. Possibly a mixture of some substance like tetra-nitroaniline, with a small quantity of another which would reduce its sensitiveness, would answer.

INDUSTRIES AFTER THE WAR.

IV.—TEXTILES (*continued from p. 732*).

Linen.

For the raw material of their industry—flax—linen manufacturers everywhere have hitherto been dependent mainly upon Russia, which contributed 80 per cent. of the total produced. Half of Russia's crop, previous to the war, was exported, a third being consumed by the peasantry of that country, and a hundred thousand tons by Russian mills. Our share was from 70,000 to 80,000 tons. Ten thousand tons are provided by Ireland, and in ordinary times an equal quantity comes to us from Belgium, France, and Holland. The best flax seems to be that received from a Belgian district which has prominently figured in recent communiqués from the Western Front, namely,

Courtrai. In normal times, Courtrai flax fetches from £80 to £100 per ton, Irish £60, and Russian £40. In value Dutch is between Courtrai and Irish. The more superior varieties of the fibre give us our damasks and finer linen. Heavy canvas and sailcloth are made from the coarser kinds grown by Russia. According to the report of the Board of Trade Departmental Committee, the whole amount of flax available for manufacturing purposes is approximately 500,000 tons, made up as follows: Russia, 400,000 tons; France and Belgium, 50,000 tons; Germany and Austria, 30,000 tons; Ireland and Holland, 10,000 tons each. Belgium has the largest consumption (130,000 tons). Germany and Austria are next with 120,000 tons. The United Kingdom utilises 100,000 and France 40,000 tons.

With regard to improving home production, attention is drawn in the report under notice to the well-known and valuable work of the Department of Agriculture and Technical Instruction for Ireland, and the British Flax and Hemp Growers' Society. Additional financial support for research and experiments, the Committee says, should prove profitable, and it is suggested that the assistance already given by the Development Commissioners might be extended with advantage. Further investigation and experiment appear to be needed principally in relation to selecting suitable seeds and manures, artificial retting, etc. Labour-saving machinery is also much wanted, and in this connection the Committee suggests certain amendments of the Patent Laws as a means of encouraging inventors. Canada and India, especially India, are mentioned as promising fields for cultivation on a considerable scale. The Government of India can, it is urged, render valuable assistance by supplying the ryots with good flax seed and by making arrangements for efficient marketing in order to ensure the preservation of the identity of the material in Europe. Flax cultivation should also be encouraged in any other parts of the Empire suitable for its growth. One of the recommendations of the Committee reads as follows: "That the Allied countries should take joint measures to conserve for each other's use in priority to other demands the supply of flax." This, the Committee considers, is the only way of meeting the preparations which the syndication of German linen manufacturers under Government control during the war are making for stronger concentration of effort when peace comes.

Flax-spinning and linen manufacture in these isles are centred chiefly in the north of Ireland, and to a lesser extent in Scotland. Though the industry has suffered, and still suffers, from overproduction, it occupies the third position among textiles so far as exports are concerned. The total annual output is valued at some fifteen millions sterling, and about nine and a half millions' worth are exported. The capital invested in the trade is stated to be about 19½ millions sterling. The following table gives the number of spindles in 1915 and of looms in 1913:—

Country.	Spindles.	Looms.
	1915.	1913.
Ireland	951,912	37,335
England	49,941	4,424
Scotland	160,085*	17,185
Total United Kingdom	1,161,968	58,944

* Including jute spindles.

In thirty-five years a decline of 300,000 in the number of spindles took place. But there was an increase of nearly 50 per cent. in looms, and there still are in existence a great many handlooms, especially in Ireland. The tendency in this trade is towards specialisation and localisation. Thanks partly to the climate, Irish manufacturers produce "the whitest and most beautifully finished fabrics in the world." Before the war, many foreign countries sent their goods to Ireland to be bleached and finished. Owing to the rise in the price of linen, cotton goods "with a linen finish" have been to some extent substituted for the real article. Dunfermline is the centre of the damask trade; Forfarshire of the manufacture of yarns and cloths from Continental flax. Labour conditions are described as not altogether satisfactory, although the operatives in the British linen trade are reputed to be the most skilful in the world. A permanent shortage of labour in Scotland is attributed to low wages. In Ireland complaint is made of irregular attendance and time-keeping, and of a "general lack of ambition on the part of the workpeople." The interesting fact is reported that three years ago the daily working hours in a leading mill in Dunfermline were reduced from nine and a half to eight without any very great decrease in production. Imported yarns are cheaper than Irish, and are said to be of better value. Great efforts have been made within the past few years to recapture the trade by installing more efficient machinery and modifying the flax mixtures. The principal markets abroad for linen goods are the United States and the British Dominions. The value of our linen exports in 1913 was £9,463,500; of our imports in the same year upwards of £2,000,000. The prevailing feeling in the home linen industry is in favour of a graduated scale of duties in manufactured goods, "distinctions being made between Allies, neutrals and enemy countries." In the case of flax yarns, opinion, we are told, is more divided, although there is a considerable demand for "very moderate duties, accompanied by anti-dumping legislation." The trade apparently is unanimous as to future restrictions upon Germany and Austria.

While the British linen industry has not been affected to any great extent by foreign competition

internal rivalry has been very keen in the past, and it appears desirable, the Committee says, that all sections should "recognise the advantage to be derived from common action to meet foreign competition after the war."

(*To be continued.*)

CHANGING CHINESE INDUSTRIES.

The rapidity with which Chinese industries, organised on more or less modern lines for manufacturing goods of foreign style or of foreign interest, has increased in the past few years, has been the subject of considerable discussion in the East, and will doubtless continue to be one of the most important features of Eastern life for some time to come. In a general way it has been the experience of foreign traders in China, as well as in other Eastern countries, that just as soon as a trade in any particular line of manufacture is developed, native factories for the production of such goods are established, the only exceptions being certain industries in which a high degree of skill may be required or where China has no raw materials upon which to work.

For example, soon after the first revolution in China it was confidently expected by many importers that there would be an immense trade in hats and caps to supply the demand for such head-gear, following the change in the style of wearing the hair and the change to foreign-style clothing generally in the open ports. Heavy imports of hats and caps were made, with the result that a large portion of the goods were sold at a loss, for the Chinese, appreciating the force of the demand for the goods, and learning that they could make hats and caps more cheaply than they could import them, started a great number of these factories, and thus supplied the demand themselves. The same has been true of boots and shoes, knitted goods, and sundry other articles. The development of the weaving of finer grade cotton goods, of woollen goods, the manufacture of paper, soap, foreign-style furniture—in short, of practically all lines of goods commonly used by the people—has progressed in a marked way.

As yet, the great mass of such manufacture is in small establishments, using little or no modern power or machinery, and usually depending almost altogether upon Chinese hand labour, but the nature and volume of the output of these concerns as a whole are of the greatest importance, for they are gradually supplanting European and American, and particularly Japanese, goods.

In most lines the increase in such modern manufacture has been more in the variety of products than in volume during the past three years. The war has affected the supply of foreign goods in some lines; high freights have affected practically all lines; while, on the other hand, high freights and the closing of many ports in Europe to Chinese products have so restricted Chinese exports, that producers of export goods have had to turn their attention to other things, with the result that new lines of industry have been developed. In Hong-Kong, moreover, there is always more or less foreign influence, and more or less of foreign capital, in manufacturing enterprises; but, at the same time, even in Hong-Kong, the great majority of all industries are in the control of Chinese capital, are managed and operated by Chinese people, and represent to a large degree independent Chinese progress in industrial development.

Because of war conditions generally, particularly the reduction of the volume of business in nearly all lines due to high freights and to the restricted buying power of most of the Chinese in South China, as a result of their inability to export goods in normal volume, the number of industrial establishments in Hong-Kong has decreased in many lines, although there is a good increase in the total number compared with the number existing previous to the war. In general, however, the more important industries have grown by the increase in the size, equipment, and output of the larger concerns and the elimination of the smaller ones. In all lines the changes are quite significant, and indicate the increasing ability of the Chinese to manufacture "foreign" goods for sale in the markets of the East in competition with similar goods imported from abroad. The Hong-Kong Blue-book for 1916 gives the total number of such establishments listed in the colony as 1,972 in 1916, compared with 1,862 in 1914.

The increase and decrease in the various industries, writes the United States Consul-General at Hong-Kong, measure in a way the course of such industries since the war began. For example, the number of furniture manufacturers increased from 103 to 178, marking the great increase in the use of "foreign" furniture and the increasing necessity of depending upon local manufacture because of high freights as well as high prime cost abroad. The number of tanneries increased from 9 to 13; the number of clock makers from 17 to 21; the number of knitting factories from 17 to 23; of paper-box makers from 18 to 25; of soap factories from 6 to 7; of rope and sail makers from 43 to 130. All these, and other increases, are due directly to the course of demand for "foreign" goods and the increasing ability of the Chinese to supply them. The number of boat-builders declined from 117 to 112, measuring the decreased tonnage of ships entering the port, for these boat-builders are largely employed in making life and other ship's boats for the shipping entering Hong-Kong. Other changes mark changing demand for Chinese goods abroad, or decreased trade due to high freights; for example, bamboo-ware makers decreased from 44 to 25, box makers from 127 to 89, copper-ware makers from 52 to 33, iron founders from 17 to 11, and ironware makers from 149 to 141.

Demand for goods to take the place of foreign-made ware is shown in the increase of tinware

makers from 60 to 90, salt makers from 5 to 25, and brick and tile makers from 22 to 27; in the establishing of a straw hat factory, which was not in existence before. The increased demand for "foreign" goods is illustrated by the increase in the number of bakeries from 42 to 51, while the decreased demand for Chinese prepared foods is shown by the decrease in canneries from 15 to 10, and ginger-packing establishments from 16 to 10. Soy factories increased from 24 to 28. Interference with the receipt of raw materials, high costs, and high freights account for the reduction of vermilion factories, white-lead factories, tin-beating establishments, and dyeing establishments.

Shipbuilding establishments and docks increased from 5 to 8, sugar refineries from 5 to 6, and tin refineries from 10 to 16. These three industries represent the largest establishments in Hong-Kong, with the exception of the cement factories and large rope works, which have been maintained at about their normal standard.

It is of some significance, so far as Hong-Kong is concerned, and to some extent in a general way, that the number of establishments in the "new territories" of Hong-Kong—that is, in the rural districts—increased from 385 in 1914 to 473 in 1916. In other words, the concerns are becoming more closely identified with the more distinctly Chinese portions of the colony.

The development of these industries in Hong-Kong is merely illustrative of a far-reaching development all over China. The industrial world already appreciates the fact that there are large steelworks at Hankow, which can produce probably the cheapest steel in the world; it also appreciates the fact that Chinese cotton-mills have made great advances in the past few years, but in general it does not appreciate that these latter are at the present time turning out increasing quantities of fancy cotton fabrics as well as the standard goods and cotton yarn heretofore produced. The advance made in the manufacture of woollen goods has also been such as to affect the market for woollen products in the East.

Further development in all these lines is unquestionably to be realised in the next two or three years, and the close of the war and the readjustment of trade in the East, following the re-establishing of peace and normal government and financial conditions, will witness an immense change in Chinese industrial and commercial affairs.

AN ARABIAN SOAP SUBSTITUTE.

Although the consumption of soap has largely increased in the Aden district, there is, says the United States Consul at Aden, an important local trade in hottom, which is used as a substitute for soap. Hottom is the Arabic name for the ash cakes which result from the burning of a desert plant that grows plentifully in this part of Arabia.

The plant from which hottom is made is a glasswort or saltwort; both *Salicornia herbacea* and *Salsola kali* are said to be found in this region and used for the purpose. The Arabs call this plant dalook, and say that it is a natural one, because it sprouts from the ground where it would not seem possible that there could have been seeds or any other means of reproduction. As a reason for their belief they point to the parched and barren rocks of Aden from which, when there is one of the rare rainfalls, these plants sprout in great numbers, but usually never to mature. The Arabs of the desert gather these plants and pile them in pits dug in the sand. They are then burned to ashes, the ashes forming a hard cake in the bottom of the pit.

Before the war, when communication with the mainland was free and subject to less interruption than at present, hottom could be had for four annas (4*d.*) per maund of 28 lb. Last year the price had risen to one rupee (1*s.* 4*d.*) per maund. The product reaches Aden by camel caravan from the mainland, one camel carrying from two to three cakes. It is estimated that 6,500 to 7,000 maunds of hottom are sold each year in the Aden market. Much greater quantities are produced and used in the Aden hinterland and in the Arabian Red Sea provinces. The local government levies a tax of a half anna per maund on all the hottom sold in Aden.

The principal purchasers of this product are the native laundrymen (*dhobies*) and dyers. From the former it derives another local name much used by Europeans. Hottom has the appearance of dried cakes of dark mud, and is frequently referred to as "dhobie mud." It is quite effective in washing very dirty or stained clothing, but is said to be sufficiently strong in alkali to have an injurious effect upon the wearing quality of the clothing if used regularly. Hottom is claimed to be an excellent mordant, and the native dyers use it in their work. A large quantity is used in this way.

The plant (dalook) has other important uses. The Arab women gather the branches and leaves and dry them thoroughly. They then crush the dried material into a powder, which is sold in the native bazaars and is also hawked about the streets. The price is one pice (¼*d.*) per cupful, the cup being about one-third of a pint in size. This form of dalook is used for cleansing the body, particularly by the Arab and the Somali women. It is invariably used when the hair receives one of its infrequent washings. The dalook powder is also used to make tough meat tender.

While hottom and dalook are still extensively used, they are slowly giving way to imported soap.

POI-MAKING IN HAWAII.

Poi, made from the bulb of the taro, produced in both wet and dry land areas, and considered the staple dish of the Hawaiians, is still one of the active commercial products of the Hawaiian

Islands, and is being shipped in quantities to the United States, reaching even New York. Taro bulbs weigh from 1 to 3 lb. each, and are usually planted in dyked-in areas, which are kept flooded with water, much the same as in the growing of rice. Broad green leaves project from the bulbs, and are used in the making of "luau," a sort of spinach.

Exports of poi have assumed greater importance in the last six or seven years, largely because of an increasing number of Hawaiians on the American mainland, principally in San Francisco and other Californian cities.

Until twenty years ago, taro was made into poi under more or less primitive conditions. The bulb was pared, then boiled, and placed in a large wooden trencher and pounded with a pestle, a little water being mixed with it in order to get a semi-liquid consistency. When beaten to a mass the product was placed in kegs, and was then ready for sale and consumption.

Poi is considered fresh on the first and second days after it is made, but is commonly preferred when three days old, as a slight fermentation sets in then, giving it a sharper taste. The poi that is made from taro grown in water areas is of either a grayish or a purplish tinge, while that grown in dry-land areas, particularly in the district of Kona, Island of Hawaii, is slightly pink in colour.

According to a report by the Honolulu Correspondent of the United States Department of Commerce, the increased acreage of sugar and pineapple plantations, as well as homesteading in the islands, and the spread of cities into suburbs which formerly were utilised for this plant, have caused the output of taro to diminish. Large areas formerly available are now occupied by suburban residential districts. The decreasing amount of taro, with the continued large demand for poi, caused prices to rise. On the Island of Hawaii the price ranged last year from 8s. to 10s. per 100 lb. Waipio Valley, on Hawaii, is one of the largest taro-producing districts, but the Hawaiians there raise it largely for their own consumption.

Machinery for the making of poi has now come into use, and manipulatoin by hand is almost entirely eliminated, while new requirements of the Board of Health as to the building of factories in which poi is made provide for concrete floors and sanitary methods of manufacture throughout.

The taro root is frequently used in island hospitals for convalescents, or for those whose stomachs are too weak to digest the customary foods.

Five poi factories at Hilo, Island of Hawaii, produce about 2,700 lb. daily. Honolulu has one large machine factory, and several small ones operated by individuals. While this branch of manufacture does not rank in quantity of output with sugar or pineapples, it is one of the most important of the island's interests, as the native Hawaiian usually requires poi for a part of each of his three meals a day.

GENERAL NOTES.

Board of Trade Advisory Council.—Pending the formation of a permanent Council to advise the Department of Commerce and Industries, the President of the Board of Trade has appointed a provisional Council consisting of representatives of various bodies, Government departments and committees, including those on Industries after the War. The Dominion Governments have been invited to nominate representatives. Five Fellows of the Royal Society of Arts are members of the Council, viz., Lord Faringdon (Financial Facilities Committee), Right Hon. F. Huth Jackson (Trade Relations after the War Committee), Mr. L. J. Kershaw, C.S.I., C.I.E. (India Office), Hon. Sir C. A. Parsons, K.C.B., F.R.S. (Electrical Trades Committee), and Sir Frank Warner, K.B.E. (Textile Trades Committee).

Victoria and Albert Museum.—In view of the suitability of monumental brasses as one means of meeting the extensive demands for memorials which have arisen out of the war, a selection of rubbings of well-known English brasses from the Museum collections has been arranged in Room 135 of the Victoria and Albert Museum. The rubbings have been classified under the headings Military, Ecclesiastical, Civil and other Costume, and illustrate the development of this form of memorial in England from the thirteenth century onwards. A few from modern brasses are also shown, including examples from a series now in process of erection upon an "Eleanor" cross at Sledmere, Yorks, in memory of officers and men from that village who have fallen during the war. It is hoped that this exhibition may give an impetus towards reviving the use of a form of memorial which is at once distinctively English in character and admirably suited for the purpose in view.

Market Sought for Capybara Skins.—In the valleys of the Orinoco River and its tributaries are found millions of "chiguires." This animal, more properly called the capybara, is the largest living rodent, and is common throughout S. America from Venezuela to Central Argentine. It is sometimes called the "carpincho" as well as the "chiguire." It is aquatic, inhabiting the marshy banks of brackish streams, and is notorious for the great damage that it does to neighbouring sugar plantations. When full grown the animal is about 4 ft. long and has a girth of 3 ft., weighing nearly 100 lb. The skin is thick and is covered with a rough brown coat of short coarse hair. The animal has a heavy flat head and very short tail. It appears, from a report by the United States Consul at La Guaira, that the chiguires have been officially pronounced undesirable animals, and the Government of Venezuela advocates their extermination. No use for their skins has, however, as yet been found.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2).

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PROCEEDINGS OF THE SOCIETY.

COBB LECTURES.

RECENT DEVELOPMENTS IN LEATHER CHEMISTRY.

By Henry R. Procter, D.Sc., F.I.C.,

Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University; Director of the Procter International Research Laboratory.

Lecture I.—Delivered May 13th, 1918.

For the comprehension of advances in leather chemistry, some knowledge not only of the chemistry but of the anatomical structure of skin is required; but, as the latter has been fully described in text-books, it may be very briefly dealt with here. The part of the skin which is converted into leather consists mainly of interlacing bundles of white fibres identical with the connective tissues of the body, and, like them, composed of a tough jelly substance (collagen), which is easily converted into actual gelatine by boiling with water. Interspersed with these, and especially abundant near the outer surface, are yellowish so-called "elastic" fibres of a different chemical nature, insoluble in boiling water, which remain in the leather but appear to take no considerable part in the tannage. Neither the white nor the yellow fibres are really living cells, but cell-products apparently produced by flattened and elongated nucleated cells lying beside them.

In the living animal there is, outside the leather-hide and separated from it by a thin varnish of different nature, sometimes called the hyaline, a layer of living nucleated cells, which form the growing portion of the epidermis, and which as they multiply push the older cells away from their source of nourishment, the blood and plasma of the leather-skin, so that they gradually die and dry up, and finally are removed by friction or washing from the skin surface. From this growing epidermis-layer originate not only hair, horns and nails, but sebaceous glands clustering round and lubricating the hairs, and still deeper sudoriferous glands. Though the hair-bulbs and their accompanying glands are deeply rooted in the leather-hide they are always surrounded by a layer of epidermal cells, continuous with the surface epidermal layer.

Chemically these epidermis products differ in a very marked way from the leather-hide, being nearly insoluble in hot water, and incapable of forming gelatine, but more or less soluble in alkaline solutions or under the influence of certain digestive enzymes. They are all, as far as possible, removed from the skin before tannage, so that it is needless to discuss their chemistry in further detail.

Collagen, the material constituting the bulk of the leather-hide is, as has been stated, closely related to gelatine, of which it is probably merely an anhydride. Gelatine appears to be one of the simplest proteids, its principal proximate constituent being amino-acetic acid (glycocoll), and it contains no groups having a benzene-nucleus. Hence, though a useful proteid food, it is incapable alone of supporting life, since it lacks some of the amino-acids, especially tryptophane, which are now known to be essential.

Fischer's recent researches on the proteids have proved that they consist of more or less complicated chains of amino-acids. An organic acid owes its acid properties to the presence of the carboxyl group $\overset{|}{\underset{\underset{\displaystyle O}{\|}}{C}} - O - H$, to the spare bond of which is attached some hydrocarbon or other organic group on which depends its special character. Thus acetic acid is simply CH_3COOH, butyric $CH_3CH_2CH_2COOH$, while stearic acid has a chain of sixteen CH_2 between the carboxyl and the terminal CH_3. Other acids may have OH groups on the chain or its branches (hydroxy-acids), or one or more phenyl groups C_6H_5 (aromatic acids), so that almost infinite diversity is possible.

Now in place of one of the hydrogen atoms united directly to carbon it is possible to substitute an NH_2 (amino) group; thus amino-acetic acid is $H_2N.CH_2.COOH$; or, looked at in another way, the acetic acid group, less H, is substituted for one of the H's in the decidedly alkaline ammonia NH_3, and the amino-acid is thus a substituted ammonia. The result is a body having both acid and alkaline properties, but very weak in both. Such compounds are called "amphoteric," and it is obvious that the acid head of one molecule can combine with the alkaline tail of another to form a chain; and in this way the proteids are built up. Such chains obviously have a carboxyl-group at one end and an amino-group at the other, and therefore like their constituent amino-acids have both acid and alkaline functions, and this fact accounts for much of their behaviour in the tanning processes.

In preparing skins or hides for tannage the first step is the removal of the hair and epidermis-structures. This is still sometimes effected on sheepskins by a regulated process of putrefaction, in which enzymes produced by bacteria bring the epidermis into partial solution, and so loosen the hair. These enzymes, or "unorganised ferments," are much akin to the digestive principles secreted by the human body, and like these are often very specific in their action, digesting one protein and refusing another. Of course the ideal aim would be to have bacteria of which the enzymes only attack epidermis, and not the white fibrous tissues; and as putrefaction usually begins in the epidermal growing layer, such bacteria are probably at first in excess; but the skins are in anything but sterile condition, and among the mixed millions of bacteria present in a tainted skin there are usually some which attack and injure the skin-tissue itself. The solution of the epidermis is not wholly the work of the bacterial enzymes, but is assisted by the ammonia evolved from the skins by their action, and it has been shown that gaseous ammonia alone will loosen the wool before there is time for any dangerous putrefaction to take place.

A much more important method, and one in almost universal use for heavy hides, is that of treatment with milk of lime. Almost any alkali can be used to loosen hair, but lime has the preference, not merely from its cheapness, but because of its very limited solubility in water, which enables it to be used in great excess without danger, and with the advantage that the dissolved lime, which alone is active, is automatically replaced as rapidly as it is taken up by the hide. If soda were used in quantities equivalent it would produce enormous swelling, and, to obtain the same gentle effect as lime, would have to be almost continuously added in successive small portions, which would greatly increase the labour. From seven to fourteen days and about 6 per cent. of lime on the weight of the hides is required for adequate liming, but much more is often used.

From quite ancient times pastes of lime and realgar, a crude red arsenic disulphide, has been used for the removal of hair, not merely from the finer skins but from the human body. It was shown by Böttger that the effect was not due to the arsenic, but to the calcium sulphydrate formed by its reaction with the lime, and equally good results were obtained from sulphydrate formed by passing sulphuretted hydrogen into lime-milk. Unfortunately the mixture will not keep, and has never been largely adopted. More recently arsenic sulphide has been largely replaced by the much cheaper sodium sulphide, Na_2S; and any of these alkaline sulphide mixtures will reduce hair and epidermis to paste in a few hours without injury to the skin, even if applied in a concentrated form. More usually, however, they are merely added in small quantity to ordinary lime liquors, of which they quicken the action, and so lessen injury to the skin without materially damaging the hair, which is of commercial value. It is worth remarking that orpiment, the yellow arsenic trisulphide, can be quite satisfactorily substituted for realgar, and is often cheaper.

For fine skins, sodium sulphide has never quite taken the place of the arsenic mixture, as it makes a thicker and coarser skin. The cause of this is that, on solution in water, sodium sulphide is resolved into equivalent parts of sodium sulphydrate and sodium hydrate, and the latter has a powerful swelling action on the skin; and if lime is added a still further portion of sodium hydrate is formed. This effect is greatly lessened by the addition of an equivalent quantity of calcium chloride, which, by reaction with the sodium hydrate, forms common salt and sparingly soluble calcium hydrate.

Just as in the case of "staling" the bacterial effect is assisted by the chemical action of ammonia, so in practical liming, the chemical action which would otherwise be very slow is supplemented by the bacteria and their enzymes

which develop in the liquor. While this bacterial action in the limes does, in some cases, lead to injury, it is much less dangerous than direct putrefaction, since many noxious organisms cannot develop in the strongly alkaline liquor. It is singular that when arsenic is used it has practically no antiseptic influence.'

Very recently Dr. Röhm has patented a process in which hair is loosened, not by ordinary chemical means, but by the direct action of the enzymes obtained from the pancreas of animals, and for certain purposes the method seems commercially successful.

Some years ago Messrs. Payne and Pullman patented a process of quick liming, consisting in first treating the goods for twenty-four hours with a 1 per cent. caustic soda solution, which sufficiently swelled and penetrated them, and afterwards for twenty-four hours with an equivalent calcium chloride solution which replaced the caustic soda in the hide by caustic lime. The liming was sufficient and complete, but as the solutions were sterile to bacteria, the goods would not unhair unless they were previously treated in a putrid soak to allow of bacterial action. If the caustic soda be partially replaced by sodium sulphide, bacterial action is no longer necessary.

Though the primary object of liming is no doubt the removal of hair, it has other important and desired effects. The fibre, from its amphoteric nature, combines with the alkali and is much swollen; the fibre-bundles are split up into their constituent fibrils, thus increasing permeability and offering much larger surface to the subsequent tanning process; and more or less of the interfibrillary cementing substance is dissolved and removed. The latter effect renders the leather softer and more porous, and hence is advantageous or the reverse, according to the object in view. It is principally due to the bacterial enzymes, and is therefore regulated to a considerable extent by the age of the liquors and the length of treatment—fresh limes swell the fibre more and dissolve less than old ones.

The hide or skin as it comes from the limes, and after mechanical treatment (now mostly by machines) to remove the hair and epidermis, is a swollen mass of gelatinous fibres containing about 4 per cent. of lime, partly in chemical combination with the collagen. Before tannage, it is necessary to remove this alkali, which would interfere in many ways with the subsequent processes; and if a soft leather is required, not only must the swelling be reduced, but in most cases a further portion of the interfibrillary substance and any residues of epidermis-matter must be dissolved and got rid of. Mere washing with water will only very slowly remove the combined alkali, since the proteid salt merely hydrolyses when the outer solution is nearly neutral, and must be carried out with water practically free of carbonic acid and bicarbonates to avoid precipitation of calcium carbonate in the hide, which is difficult afterwards to remove.

When a firm or only a moderately soft leather is required, the use of acids to decompose the hide-lime compound is now general. By far the cheapest agents are the "strong" mineral acids, hydrochloric and sulphuric, the former having the advantage of a very soluble lime salt. Unfortunately the amphoteric hide is as ready to absorb acids as alkalies, and is equally swollen by them, so that to get good results exact neutralisation without excess of acid is imperative, and to secure this demands intelligent chemical oversight, and hence tanners have largely fallen back on the use of much more costly but safer "weak" organic acids. The sour taste and swelling properties of an acid depend on the concentration of hydrogen ions in its solution, and hence on the completeness of the ionisation, and while hydrochloric acid is almost wholly ionised in dilute solution and all its acidity is exerted at once on the pelt, lactic and acetic acid are only ionised to a very small extent, and consequently swell little; but as the acid is consumed, a further portion ionises and maintains ionic concentration so that in the end as much lime is neutralised as by an equivalent quantity of a "strong" or highly ionised acid.

It is, however, possible to use the "strong" acids with perfect safety if they are added in insufficient quantity completely to remove the lime, and the deficiency is made up with a weak acid; or to a sufficient quantity of the strong acid, the salt of a weak one such as sodium acetate is added so that in either case the operation is completed with the weak acid only.

In the case of sulphuric acid, as calcium sulphate is rather insoluble, it is best to use at once enough of the weak acid to complete the deliming, and afterwards to treat the solution with a calculated quantity of sulphuric acid to precipitate the lime as sulphate, and again liberate the weak acid, when the liquor can be used a second time with only a small

addition of organic acid to make up losses. The economy is worth making, for even at pre-war prices, while 28 lb. of lime could be neutralised with sulphuric acid for 0·8*d.* the same work with acetic acid costs 10*d.*, and with lactic acid 1*s.* 6*d.* Nitre-cake, a crude sodium bisulphate which is now much recommended by the Government as a substitute for sulphuric acid for many purposes, is not suitable for deliming, as in addition to the large quantity of sodium sulphate which it contains, and which lessens the solubility of the lime sulphate formed, it is generally contaminated with traces of nitric and nitrous acids which discolour the leather.

In place of organic acids, boracic acid, which is extremely weak and quite incapable of producing acid swelling, is often used, and the cheap sulphurous acid from burning sulphur deserves more attention than it has received.

In many cases, a simple acid deliming is sufficient even for dressing leathers where extreme softness is not required, and it effects considerable economy in hide-substance as compared to the bacterial and digestive methods which must be later described For this purpose the previous liming should be somewhat long, and conducted in moderately old and bacterial limes to ensure sufficient removal of the interfibrillary substance, and the acids used must be so weak as to produce a minimum of swelling while removing the whole of the lime. This is secured by the use of any weak organic acid, with the addition of sufficient of its neutral salt to repress still further the already weak ionisation, according to the well-known ionisation law. This can be done by using repeatedly, after strengthening with acid, liquors which contain the calcium salt of previous operations. Salts of weak bases with strong acids, *e.g.* ammonium chloride, may also be advantageously used, liberating ammonia only, which has little swelling effect.

The older methods of removing lime and producing the required flaccidity of the skin, depend on the use of somewhat disgusting fermenting mixtures of pigeon-, or, still, worse, of dog-dung. In these the lime is removed mainly by the amino-acids and amine salts, produced by bacterial action, while at the same time the interfibrillary substance and the residues of epidermis and cellular structures are digested and rendered soluble by the bacterial enzymes. The latter action is so strong in the ordinary "dog-puer" at a temperature at 80° to 90° F. at which it is generally used, that in a few hours the entire skin may be dissolved. Undesired bacteria, which are always present, are also apt both to stain the skin and to corrode its texture, so that with the most intelligent management the process is dangerous as well as disagreeable. It may be added that septic and pathogenic bacteria are not infrequent.

The first improvement of this crude method was made by Joseph Turney Wood, to whom we owe most of our knowledge both of the bacteriology and the chemistry of these processes, gained in the limited leisure of a strenuous business career. He prepared a mixed but otherwise pure culture of certain bacteria which produced the necessary depleting effect without injury to the skin, and a suitable culture-medium for it by peptonising gelatinous matter by acids, in conjunction with ground bone, to supply the necessary phosphates. The preparation was produced commercially by him in conjunction with a German firm, and has been used under the name of "Erodin" with a considerable degree of success on calfskins. Wood also showed that a solution of enzymes prepared from puer liquor, with the addition of an amine salt to neutralise and dissolve lime, would produce a satisfactory puering without the presence of any living bacteria. About the same time the suggestion was made that the puer owed its effect to digestive ferments of the dog which had escaped destruction. As all these digestive enzymes are readily putrefiable, and the dog-dung is always kept in a wet condition some time before use, this did not seem inherently probable. But Wood showed that the action could not be due to pepsin, which only acts in acid media, while the working puer-liquor is always alkaline; but that conceivably the pancreatic ferments, which require alkaline additions, might have some effect, and his experiments with pancreatin, an impure trypsin enzyme, gave a somewhat imperfect puering. Wood did not at that time carry the matter further, though he protected the idea in an American patent, but later it was taken up by Dr. Röhm, who, by improved methods of preparation of the pancreas extract and the addition of ammonium chloride to solubilise lime, produced a mixture which under the name of "Oropon" has proved quite successful for calfskins, though for certain uses of sheep, goat, and lamb skins, the practical problem cannot be regarded as wholly solved.

After skins have been puered they are usually "drenched," to cleanse them and remove

residual lime, and occasionally drenching is employed without previous puering. The drench liquor is simply an infusion of bran made with hot water and allowed to ferment either with the skins or before introducing them. The nature of the process has been thoroughly investigated by Wood, who finds that the carbohydrates are first converted into glucose by an enzyme, cerealin, which is naturally present in the bran, and that the glucose is further fermented by bacteria, lactic, acetic and carbonic acids and hydrogen being the principal products. The active bacteria are B. furfuris α and β (Wood), and are possibly originally derived from the puered skins. They are only active in very weakly acid liquors, and die out, without frequent change of medium, from the poisonous effect of the acids they produce, so that the process is, to a large extent, a self-regulated deliming, in which the concentration of the mixed acids is kept constant by their effect on the bacteria. The gases evolved have the effect of floating up the skins at intervals, which are a rough indication of the progress of the operation. The skins, when properly drenched, are white and soft, but no longer quite so flaccid as when they came from the puers. The process is best conducted at about 70° F., and if carried too far the gases evolved in the interior of the skins produce blisters and pinholes, and injurious fermentation from "wild" bacteria may also occur.

It is obvious, from what has been already said, that very much in the tanning process hangs on the property of hide fibres of swelling in acid or alkaline solutions, and "falling," or becoming thin, loose, and flaccid under other conditions; and I must try to give you some idea of what has been recently done to explain these effects, though I admit the subject is an extremely difficult one, and much of the work of myself and my collaborators has not yet found its way into chemical text-books.

I do not know whether I may assume that most of my audience are familiar with the ionic theory, and while time forbids any lengthy explanation, yet without it much of what I am going to say, sufficiently difficult in itself, will be entirely incomprehensible. If atoms are likened to small glass bulbs, each with a definite charge of electricity, positive or negative, sealed inside, it is obvious, on ordinary electrical principles, that the positive bulbs will attract and adhere to the negative, and this, in a very rude way, is a picture of ordinary chemical combination. If, however, such adhering bulbs are placed in a conducting liquid, such as water, their charges will be neutralised by opposite ones condensed on their surfaces, and they will cease to attract each other and be free to move *in* the liquid, though they will recover their attractions if withdrawn from it. Water acts in this way, as an "ionising liquid"—the negative Cl' and the positive Na^+ joined together in solid salt are free to separate within a sufficiently dilute solution; and as all atoms possess the violent vibratory motion we call heat, they tend to separate and diffuse, and exercise pressure, which is called *osmotic*, on the liquid surfaces which confine them. In any solution there is always a definite proportion of such free ions as compared to those which still remain combined, but in "weak" acids and bases, and especially in water itself, this proportion is a very small one.

There is a process known as "pickling," which has sometimes been employed for deliming and as a preparation for chrome and other tannages, as well as commercially, on a very large scale, for preserving wet sheepskins for export. This process involves both swelling and falling, and will in itself convert skin into a sort of leather, so that manifestly its full explanation would throw a good deal of light on the whole theory of tanning.

This process has occupied my attention at times for the last twenty years, and from it I have learned much and hope to learn more, for such an investigation never ends, but always opens up new and often unexpected problems, and the same causes which produce the pickling of sheepskins may be shown to be responsible for some of the most important actions in the human body, and, among others, in all probability for muscular contraction.

The pickling process essentially consists in swelling the skin with an acid, usually in practice sulphuric or hydrochloric (but any acid will do which will cause swelling); and then treating the swollen and gelatinous pelt with a strong solution of common salt in which it "falls," or becomes thin and white, and on being squeezed between the fingers can be wrung out like a rag. We have then a felt of unswollen fibres which do not adhere on drying, or at least may be easily separated by stretching, leaving a very complete white leather, which, however, if placed in water quickly returns to the condition of swollen pelt. I wanted to know why the fibre swelled in acids and why it shrank in salt solutions, for these were obviously fundamental

questions in leather manufacture, and I began my work on sheets of gelatine instead of on actual skin, because they were chemically almost identical, while gelatine was uncomplicated by the capillary structure of the natural fibrous tissue, so that the actual swelling of the jelly itself could be accurately weighed and measured. I used hydrochloric acid for most of my experiments as a simple monobasic acid, identical with that contained in common salt. My first step was to determine the effect on swelling of gradually increased concentration of acid solutions, and at once a singular fact became obvious. The swelling did not increase proportionately to the concentration of the acid, but reached a maximum at a very low concentration (about 1 gramme-molecule in 5,000 litres of water) and then steadily sank with increasing concentration to a point when the acid became strong enough gradually to break up the gelatine chemically, and the experiment could not be further continued. If, however, salt were substituted for further additions of acid no chemical breaking up occurred, and the shrinking could be continued till the gelatine became a horny mass.

When very small quantities of acid only are added to the gelatine it remains at first quite neutral to such indicators as methyl-orange or Congo-red, which react to free acid only, and the acid is evidently neutralised by the gelatine, or, in other words, has formed a gelatine-salt, though as more acid is gradually added there is no sudden change as there would be with soda or lime, and the indicator passes over quite gradually to the acid condition. In former times this was used as an argument that no really definite combination took place, but it is now known that with weak bases, such, for instance, as gelatine or alumina, the salt can only exist in presence of some amount of free acid, without which it breaks up again by combination with the elements of water to re-form the base and acid. Thus a solution of alum is always sour and contains free alumina, and its reaction to indicators is quite gradual.

We have now means of determining the free acid actually present in a given mixture, and as the process (hydrolysis) follows known laws, we can calculate the composition of the neutral salt, or, in other words, the weight of base which will unite with one equivalent of acid can be ascertained. I have calculated in this way the combining equivalent of gelatine as a base as 839, a large value, but much lower than had been previously supposed. The value is probably not quite accurate, but cannot be far wrong. This does not say that the actual molecule is only 839 times the weight of a hydrogen atom, but only that this is the weight of the smallest individual portion of the chemical substance, gelatine, which can exist. At ordinary temperatures, many such chemical individuals may be linked together to one large molecule by what is called polymerisation, but it seems probable that as the boiling-point of a water-solution of gelatine is approached, 839 or some approximate value represents the actual molecular weight.

It must be understood then that every mass of gelatine jelly or every gelatinous hide-fibre in an acid solution of any definite strength is in equilibrium with the surrounding solution, that is that it contains water, gelatine salt, free gelatine, and free acid in such proportions that there is no tendency for either acid or water from the surrounding solutions to pass either into or out of the jelly, though both can pass freely through its surface.

In applying these facts to our problem we may simplify the task to a certain extent by neglecting the un-ionised substances, which in this case affect it only indirectly, and confining our attention to the ions themselves which are the real active agents.

If we admit the existence of gelatine salts, we have to consider the effect of their ionisation on the swelling. The gelatine-ion remains colloid, that is, it tends to agglomerate into masses or large particles which do not diffuse, and consequently exert no appreciable osmotic pressure, while the ionised salt still remains a jelly or a colloidal solution. The Cl ion, on the other hand, tends to diffuse and exerts osmotic pressure, but cannot leave the jelly on account of the electro-chemical attraction of the gel-ion. It therefore swells the jelly, thus drawing into it the outside acid solution. This, however, contains the hydrogen and chlorine ions of the ionised acid in equal quantity, and while the former can enter the jelly without hindrance, the latter is opposed by the osmotic pressure of the ionised Cl already inside. The results are that the acid which enters is less concentrated than that outside, that the concentration of Cl within is greater, and that of H less in the jelly than in the outer solution, and as the acid H cannot enter without its associated Cl, a layer of positive H^+ forms outside the jelly surface, opposed and balanced by a similar layer of negative Cl' within. Thus the two sides of the surface are in different electrical

condition, or, in electrical language, there is a potential between them (Donnan's "Membrane Potential") and the surface layer outside the jelly has a small + electric charge. If, instead of being acid, the jelly and outer solution were alkaline, say with soda, the gelatine being amphoteric would form a sodium gelatinate in place of a gelatine chloride, and the charge would be negative instead of positive. It is obvious that between these conditions there must be an "isoelectric" point of neutrality at which there is no potential charge. This does not necessarily occur at the exact acid and alkaline neutrality of water, but is dependent on the relative acid and alkaline affinities of the individual proteid. In gelatine and hide-fibre, it is slightly on the alkaline side, and this is the point of minimum swelling and greatest flaccidity of the skin, and is generally approximately realised in bating and puering processes which have that aim. With regard to the actual tanning process, these charges are also of the highest importance.

The osmotic pressure tending to swell the jelly is therefore a balance of two opposing forces, that of H^+ pressing in, and of Cl' (or some other acid-ion) pressing out. Donnan has shown that when the jelly and its outer solution are in electrical and chemical equilibrium, the proportions of the two are connected by the law that the H^+ multiplied by the Cl' within the jelly must equal the $H^+ \times Cl'$ of the outer acid. Now the H and Cl of the outer acid are equal, while in the jelly Cl is in excess, and the *sum* of equals is always less that that of unequals which give the same *product*. Thus the *sum* of $4+4$ is 8, that of $8+2$ is 10, yet both give the *product* 16. There is thus always a slight osmotic force tending to swell the jelly, greater as the two factors are more different. The greatest difference occurs when the quantity of free acid is very small and the chlorine in the jelly is almost entirely in the form of gelatine salt, and it is there that we get the greatest swelling. As the concentration of the acid and its quantity in the jelly increases the difference becomes less and the swelling diminishes, and if we add salt also in large excess, as in pickling, both almost entirely disappear.

We have therefore accounted for the swelling force, and shown that as it increases or diminishes the swelling does the same, and not merely in a general way, but mathematically and quantitatively, and that this force only quite disappears when the concentrations become infinite and equal. As, however, the swelling does not go on to infinity and solution, there must be some opposing force, which, when the swelling reaches a definite equilibrium, is equal and opposite to the swelling force. This is apparently the attraction of one gelatine particle for another, the elastic cohesion of the gelatine; and it seems to follow the Hooke's law generally applicable to elastic strains, in that it is proportional to the volume-extension. The exact nature of such strains has not yet been determined, but in the case of colloids it may have much to do with surface tension. That it is sufficient to account even for the intense contraction under the influence of salt is shown by its magnitude when water is withdrawn by ordinary evaporation—a drying film of gelatine will often actually tear away the surface of glass to which it adheres. In another respect it resembles other elastic forces, since it diminishes rapidly and the swelling increases with increased temperature till at the melting-point of the jelly it apparently disappears, and the swelling goes on to complete or colloid solution. As, however, even in solution, the gelatine particles can be shown to retain their electric charges, it is probable that at least at temperatures below 70° C. they still continue as separate particles suspended in a surrounding liquid.

CULTIVATION OF THE CASTOR-OIL PLANT IN COLOMBIA.

Considerable interest is being shown in Colombia, both in the Department of Santander and in the Department of the Atlantic, in the castor-oil plant. This plant has been grown for several years in a small way in Santander, but its possibilities as a money-producer have only recently become evident as a result of the high prices of castor oil. The interest evoked was largely through the discovery of a local druggist, who found he could produce his own castor oil much cheaper than he could import it. The first yield was so satisfactory that others commenced to plant, and at present there are approximately 350 acres under cultivation near Barranquilla (Department of Atlantic), and about 1,500 acres in the Department of Santander.

From a report of the United States Consul at Barranquilla it appears that the Santander bean is larger than that grown on the coast, but is said to yield a smaller percentage of oil. The coast bean gives a yield of 50 to 60 per cent. in oil, while that from Santander gives only 40 per cent.

The plant grows best in sandy soil well watered, but it has been found that too much water is not good for it. Some planting done in land that was almost marshy gave very poor results. The seeds

are planted $6\frac{1}{2}$ ft. apart, and the plant matures in from three and a half to four months. Estimates on the cost and profit of cultivating this bean were based on a yield of 2 lb. of seed per plant per year, but actual results have shown that this yield will be nearer 4 lb.

It is calculated that the cost of planting and harvesting one hectare (2·47 acres) for one year is £8. One hectare contains 2,500 plants which, at the low estimate of 2 lb. per plant, will yield 5,000 lb. of castor beans. At 1*d*. per lb. the crop would be worth £20, leaving a net profit of £12. The price mentioned, however, is much too low, as the seed fetched 2*d*. per lb. last year in Barranquilla.

The harvesting of the crop is done by children, who are sent out daily to gather the ripe pods. These are placed in the sun to dry, and when brittle are broken up by hand. The method is satisfactory at the present prices and on small farms, but the larger growers are interested in obtaining a satisfactory machine to thrash the pods. It is said that such a machine was formerly purchased in England for service in India, but that it cannot now be obtained.

Large shipments of castor-seed meal and of the beans were made last year to New York, and still larger shipments are expected to be made in the future, especially if a satisfactory method of thrashing can be found.

No castor oil is imported into Colombia now, adds the United States Consul, except occasional small shipments of the odourless or aromatic product.

INDUSTRIES AFTER THE WAR.

IV.—TEXTILES (*continued from p. 744*).

Jute.

The raw material of the flourishing jute industry is a monopoly of India, and practically of one part of India. The Board of Trade Committee tells us that cultivation of this, the cheapest of all textile material and certainly not the least durable, is confined to the Presidency of Bengal, the Province of Eastern Bengal, Assam, Cooch Behar and Nepaul; but Sir Charles C. McLeod, in the admirable paper he read before the Society three years ago,* mentioned that an inferior species grown on the Madras side is now in considerable demand owing to improved methods of treatment, better packing, and greater cheapness. As the Committee observes, the cheapness and durability of this fibre cause it to be in constant and universal use throughout the world for the manufacture of sacks, bags, wrappers, and packings for all sorts of raw and manufactured articles of commerce. It is the basis of linoleum and floor-cloths, and is employed in a great variety of other ways. How extensively it has been used for sandbags in the present war is well known.

The question is often asked why in India alone the production of jute is a "business proposition." Higher cost of labour in Egypt and other countries where experiments have been made, unsuitability of soil and climatic conditions, are the reasons given by the Committee in its report. "In India, copious rains alternating with fine weather are essential in the period of growth, and thereafter an abundant rainfall combined with the melting of the snow on the mountains is necessary for the maintenance of the level of water in rivers, ditches and ponds in which the plant must be steeped and retted before the fibre is available for commerce." The area under cultivation is approximately three million acres, though sixty million acres in Bengal and Assam are suitable. That there is not greater expansion is attributed in the report to the market price of raw jute. According to Sir Charles McLeod, the determining factor is labour. The Committee supports the view he put before the Society that a deterioration of quality noted in recent years arises from the fact that enhanced prices have caused the ryots to produce larger crops than they are able to handle. Sir C. McLeod thinks that more scientific methods of cultivation and a careful selection of seeds would double the out-turn per acre. The Committee notes the efforts already made by the Government of India in this direction, and urges further development on the same lines.

The jute crop of 1913-14 consisted of some two million tons, which were distributed roughly as follows: India, 1,100,000 tons; United Kingdom, 300,000; Germany, 160,000; France and America, 120,000 each; Austria, 60,000; Italy and Russia, 50,000 each; Belgium, 20,000; other countries, 20,000.

India has not only a monopoly of the raw article, but is at the head of all jute manufacturing countries, dominating the world's markets in the coarser Hessians, gunny bags, yarns, etc. Dundee had the start of Calcutta by some two decades, and at one time was the sole source of supply for jute goods. The extent of the competition she has experienced since the early seventies of last century is indicated by a table showing the distribution of the Indian crop (in bales of 400 lb.). The figures are as follows:—

	1874.	1884.	1894.	1904.	1914.
Total crop	2,560,000	3,750,000	4,800,000	6,900,000	10,000,000
India	460,000	900,000	2,000,000	2,900,000	5,000,000
Dundee	1,000,000	1,200,000	1,200,000	1,295,000	1,295,000
Continent	300,000	650,000	1,600,000	1,800,000	2,610,000

* *Journal of the Royal Society of Arts*, Vol. XLIV. p. 105.

It will be seen that for some time the industry has been stationary in this country. The Committee was informed that the cost of production, exclusive of raw material, is probably about £12 per ton in Calcutta, as against £25 per ton in this country. Moreover, the Indian mills work from seventy to eighty hours a week, the employees being largely "young persons." Of course, more labour is required to do a given quantity of work than is the case here, but this, it is said, only counteracts to a very limited extent the low wages. It is estimated that in July, 1914, the operatives in the home trade numbered 51,000, of whom only 16,000 were of the male sex. The Indian mills employ about a quarter of a million hands, and the net profit of the various factories in 1913-14 is stated to have been about £1,800,000. From the beginning of the industry Germans largely controlled the distribution of Dundee's goods on the Continent, and it was Germany that erected the first jute-mill outside Scotland. Dundee supplied the machinery, and sent overlookers and operatives "to teach the Germans how to work it." Others followed Germany's example, with the result that by 1879, when the Protective policy of the Continent came into full operation, Dundee had lost the bulk of its Continental trade. "The method adopted," says the Committee, "appears to have been virtually the same in all Continental countries. In the first instance bags were excluded by tariff, and cloth was admitted free. As the industry developed, a duty was imposed on cloth, but yarns were imported free, until finally the satisfactory spinning of jute yarns was achieved, and the market was closed to British goods, with the exception of specialities. The menace to Dundee in the future appears to be that these Continental countries, and especially Germany and Austria-Hungary, are no longer confining themselves to the supply of their home trade, but are beginning to compete in the open markets of the world, notably in the Balkan markets." The following table explains itself:—

Country.	Raw Jute Manufactured.	Retained, per cent.	Exported, per cent.
	Tons.		
India	1,100,000	40	60
United Kingdom	300,000	60	40
France	120,000	75	25
Italy	50,000	80	20
Russia	50,000	100	0
Belgium	20,000	?	?
Germany	160,000	90	10
Austria	60,000	90	10
United States	120,000	100	0

In discussing probable post-war conditions the Committee anticipates that at the conclusion of peace there will come from Germany and Austria alone an immediate demand for at least 300,000 bales. Allied and neutral countries will require exceptional amounts to make up for the shortage caused by the war. Effective control of jute distribution may be regarded, says the report, as one of the most powerful weapons to be held in reserve should the necessity arise for penalising enemy countries or enforcing favourable commercial treaties. In conformity with the views unanimously expressed by the witnesses representing the trade, the Committee recommends the imposition of an export duty (£5 per ton was proposed by experts) on shipments of the raw material from India to all destinations with a total rebate in favour of the British Empire, total or gradual rebates for the Allies, and graduated rebates in the case of neutrals offering reciprocal concessions, a portion of the money derived to be applied towards stimulating production and encouraging more scientific cultivation. It is estimated that the duty would bring in from two to three millions sterling. If afterwards there should still be a deficiency in the supply the remedy suggested is a system of rationing enemy and neutral countries. The demands of British and Allied manufacturers would be met without limit, subject to restrictions upon re-export. It would probably be possible to allow neutrals to obtain the bulk of their requirements for their own consumption, but licences to enemy countries would be restricted to the limited amount after satisfying the rest of the world.

One member of the Committee, Mr. John W. McConnel, disagreed with the "definite recommendation" as to an export duty, on the ground that further inquiry seemed to be necessary. The Committee, it seems, "was not in a position to take evidence as to the needs and wishes of producers and consumers in India." Another member, Mr. Theodore C. Taylor, M.P., was also unable to concur with the majority. *Inter alia* he is of opinion that an export duty would be "unfair to the Indian producer and impolitic as respects our relationship with India."

Those who signed the report without reservation on this or any other point were Sir Henry Birchenough (Chairman), Sir F. Forbes Adam, Mr. James Beattie, Mr. T. Craig-Brown, Mr. Edward B. Fielden, Mr. James W. Hill, Mr. J. K. Kaye, Mr. Edward H. Langdon, Mr. H. Norman Rae, Sir Frederick H. Smith (now Lord Colwyn), Mr. Robert Thompson, M.P. (since deceased), and Sir Frank Warner.

(To be continued.)

THE PEANUT INDUSTRY OF CHINA.

Peanuts are not indigenous to China, having been introduced some time previous to the eighteenth century. They are now grown in all parts of the country except the higher regions.

Chinese peanuts are said to average 46 per cent. oil. The oil is extracted, and exported in large quantities, for use in cooking, as a substitute for olive oil, and largely in the manufacture of soap. The value of peanut oil exported in 1915 exceeded by more than 50 per cent. the value of all peanuts shipped. After the extraction of the oil, the product remaining is formed into cakes, which are used as fodder, poultry-feed, or fertiliser. A large part of the peanuts exported to Europe is used in the manufacture of oil and soap.

The greater part of the peanuts of China used commercially come from the provinces of Shantung, Honan, and Chihli. Shantung peanuts are ordinarily larger in size, while those from Honan and Chihli are said to be somewhat richer in oil, and consequently usually fetch better prices.

Prior to the war the port of Kiaochow (Tsingtau) held first place in exports of both peanuts and peanut oil, shipping, in 1913, 44 per cent. of all the nuts exported and 43 per cent. of the oil. Since then its trade has been diverted largely to Chefoo, Hankow, and Shanghai. Customs returns for 1915 show Tientsin and Chinkiang as the principal export ports for peanuts in the shell. Practically all of these shipments were made, however, to other Chinese ports and Hong-Kong for transhipment and to Pacific ports of Russia. Of peanut kernels Hankow and Shanghai shipped 75 per cent. of the total, the amounts from the two ports being about the same. Those exported from Hankow, however, all went to other Chinese ports—principally to Shanghai — whence they were largely transhipped abroad.

On account of its accessibility to the centres of production and its shipping facilities, Shanghai is the natural port for ocean shipments of peanuts. Large quantities are therefore brought down by local dealers and stored in their godowns awaiting shipment, or else transferred direct from coastwise craft to sea-going vessels. In the latter case the necessary inspections are made at the sources of supply. The former method is considered preferable, in that the exporters have the opportunity to prepare and inspect their cargoes just before the ocean voyage, and to see that proper ventilated storage-space is secured for the shipment.

According to a report by the U.S. Consul-General at Shanghai, the peanut season begins about the end of November and continues to June or July. When the crops are gathered the peanuts are stored in godowns in the vicinity, whence they are shipped as required. No attempt is made to "cure" the peanuts—that is, they are not subjected to any treatment to hasten their hardening, this being left to nature. They soon lose their excess moisture in storage, and it is generally safe to make shipments by the middle of December. It is said that peanuts are likely to get mouldy *en route* if when shipped they contain more than 8 per cent. moisture.

At the points of production peanuts are generally sold as fair, average quality of the season, sound at time of shipment, containing not more than 3 per cent. of stone, mud, dirt, or loose shells. If kernels are sold, the shelling is done at the supply point mostly by hand.

CITRUS CULTIVATION IN SURINAM.

Attention is drawn, in the *International Review of the Science and Practice of Agriculture*, to an article by J. A. Liems on the above subject, published in the *Bulletin* of the Departement van den Landbouw.

There are many orange trees scattered about the plantations in Dutch Guiana, but orange groves have only been formed there more or less recently; the first, planted at Vredenburg, contained 142 trees. Near Surinam is a nine-year-old grove covering about 4½ acres, and another covering nearly 34 acres, composed of native citrus trees from three to eight years old. Other groves have been planted near the Commewyne River. In order to increase the cultivation of citrus trees the Department of Agriculture of the Colony has recently distributed, amongst small holders, a large quantity of grafted orange trees. Of all tropical fruits the orange is the best adapted to export. Exportation was begun in 1907, and since then the local Department of Agriculture has shipped oranges and tangerines to Holland. From the point of view of the prices obtained the results were encouraging. In 1909, 0·24*d.* was obtained per orange sold in Holland; in 1910, ½*d.*, in 1914, 0·36*d.* In 1911, as a result of delay in the departure and voyage of the boat carrying them, the oranges arrived in an unsaleable condition. In 1912, as the crop was poor, no fruit was exported. The experiment was a complete failure in 1913 as a result of the unfavourable shipping conditions. As the boats were not suitably fitted for carrying oranges, a large number of damaged fruit was found in all the shipments to Holland. According to the author, there is no doubt that, when normal conditions prevail again, the shipments may be restarted under conditions favourable to the keeping of the oranges during transport, so that a better price will be obtained for the fruit exported. In Surinam the oranges ripen from July to October, the months during which they are absent from the European market. As Surinam oranges are larger and of better flavour than European ones, they are much in demand on the Amsterdam and Dutch inland markets.

The rules to be observed in sowing seed, care of the seedlings in the nursery, grafting, final plantation (in squares, 25 feet apart, or about 70 trees per acre), cultural methods, etc., are given.

The chief disease is gummosis, found in groves where the trees are too close together. The chief injurious insects are ants, which greatly damage

the orange trees, and scale insects, which attack particularly young nursery plants.

As the cultivation of orange trees is relatively recent in Surinam, it is too early to state which foreign varieties are to be recommended. Lamb's Summer variety produces, in sandy soil, good fruit much appreciated in Europe, but ripening a little late. The Washington Navel orange is less good and less juicy than the native fruit. The Director of the Botanical Garden and the author have sought the best varieties for propagation among the native varieties.

A yield of 1,000 fruit per adult tree is not exceptional. At Vredenburg, in 1911, a tree gave 3,800 fruit. The average yield per tree may be placed at 500 fruit. Estimating the sale price at ¼*d.* per orange, an acre of 65 trees with an average of 500 fruit would bring in about £40; from this must be subtracted the cost of cultivation, placed at about £4.

The methods of packing are described, those used in California for shipping oranges being specially recommended.

COIR-MAT INDUSTRY IN THE PHILIPPINES.

Investigations by the Division Industrial Supervisor for the Province of Pangasinan have been made a basis for the assertion that enough coconut husks are annually wasted in the Philippines to make coir mats with a wholesale value of 22,500,000 dollars. These husks are usually thrown into the rivers and allowed to float out to sea, or they are burned or allowed to rot on the ground. During the year 1916 there were 735,000,000 coconuts gathered in the whole archipelago. The cleaned fibre from the husk of each of these nuts would have weighed approximately 0·22 lb. The fibre or coir from twenty of these nuts would have made a good doormat such as retails in the United States for 1·50 dollars and in the Philippines for two dollars. It is estimated from experience in cleaning this fibre that approximately 80,850 tons of coir might have been realised from the husks of the coconuts grown in the Islands during 1916.

At present, according to a report by the correspondent at Manila of the United States Department of Commerce, only a few hundred coir mats are made in the Philippines, and these are produced by children. Special efforts are being made to develop their manufacture as a household industry in the coconut provinces, particularly in Pangasinan. The industrial departments of the schools are giving special attention to the work. It has been demonstrated that children from eight to twelve years old, with practically no cost for apparatus, can produce mats of good commercial quality. The equipment employed consists of a frame of cheap wood, some bamboo pegs, and a pair of large scissors, or a sharp bolo.

The coir is obtained from the fresh husk of the coconut by pounding it on a log or stone with a mallet or stone, implements which are always at hand. Before the schools, under the direction of the industrial supervisor, took up the manufacture of coir, it was believed that expensive retting vats were needed, and that the retting process would take approximately six months. The experiments in the schools have shown that this long and expensive process is entirely unnecessary. It is the purpose of the Bureau of Education to introduce the making of coir mats among the people as embroidery making and hat making are now carried on in the household. In this way the grower of coconuts may utilise both his material and his time.

There are now fourteen provinces in which 1,000,000 to 9,000,000 coconut trees are bearing. In each of these Provinces, it is estimated, enough unemployed labour is available, if properly organised, to build up a large volume of business in the manufacture of coir mats. The conditions seem to be favourable for employing both home and factory workers in the making of the mats. The coir rope from which the mats are made can be spun rapidly by children of eight to ten years, using a simple contrivance made from a coal-oil box, a wooden roller, and a short piece of coir rope. If there were a central factory in which this coir rope could be used, and a permanent market for it established, the rope could be produced in the coconut centres and despatched to the factory, thereby avoiding the necessity of transporting the whole husk.

Most of the coir mats used in the United States are obtained from Java and Singapore by way of Europe.

EMERALD MINING IN COLOMBIA.

The emerald-mining industry in Colombia dates its origin long before the Conquistadores of Spain turned their eyes towards the Western World. When Bogota was first settled in 1534, the Spaniards made every effort to discover the location of the emerald deposits which were known to exist not many miles from the settlement. Their endeavours were long frustrated by the opposition of the powerful Indian tribes of the district. Finally, however, in 1594 mining operations were begun, the work being carried on wholly by Indian slaves. Great treasures were taken from the district during the Colonial period, a very large portion of the revenues going to the Spanish Crown.

A number of mines were worked by private interests during the first thirty years of the Republic, and fair results were obtained. In 1848, the Colombian Congress decided that thereafter all emerald mining would be carried on under the supervision and for the benefit of the Government, profits to go into the National treasury. This state of affairs continued until 1908-9, when a British company obtained a concession to develop an extensive area. The company was provided with a fair amount of capital and carried on considerable development work, but without

much success. The enterprise struggled along until 1914, when it was deemed advisable to wind up the company's affairs. The mines were taken over by the Government under judgment for £250,000, and the shareholders received back a portion of their investment. Since the outbreak of the war in Europe, and the consequent cutting off of the principal market for the gems, operations have been confined by the Government to the maintenance of the property.

According to a report by Mr. F. M. Halsey, special agent of the United States Department of Commerce, the mines are difficult of access, being three or four days' journey by mule back from the nearest railway. The emeralds are sent through Bogota over the long and expensive rail and water routes to the world's markets.

Colombia is the chief emerald-producing country, the output in a normal year amounting to about 800,000 carats. That the industry is likely long to continue a source of wealth to the Republic is indicated by the fact that, in addition to the already developed field, two new deposits have been located. However, these deposits (at Cosquez and Somondoco) are at present inaccessible owing to transportation difficulties. At least one of the newly discovered fields, adds the special agent, is as rich as the Muzo deposit now being worked.

THE SOUTH AFRICAN OSTRICH INDUSTRY.

Only five years ago the ostrich was the most pampered and highly-valued possession of many South African farmers. Now there is little interest even in the most perfect of these birds.

In 1911, 1912 and 1913 lucerne lands suitable for ostriches, with a good water-supply, were selling at remarkably high figures. A pair of the best breeding ostriches easily sold for £1000. Super-prime feathers (*i.e.* perfect white wing feathers from the cock bird) fetched £24 to £28 a pound on the public market in South Africa. In 1917 the best feathers produced could probably be purchased for £10 to £12 a pound.

It was in the late sixties, writes the United States Consul at Port Elizabeth, that the commercial aspect of the ostrich plume presented itself to the South African farmer. It is probable that the birds had been domesticated on some few farms for many years previous to that time, but about the period mentioned feathers began to be exported to London and thus became a commercial commodity. From a very small beginning the business developed into a trade amounting to hundreds of thousands of pounds annually, but met with a check in 1914, and now there is an almost complete cessation of demand for feathers.

It is difficult to imagine a more ideal existence than that lived by many of the ostrich farmers in the heyday of prosperity. South Africa is properly called "The Land of Sunshine," and except for a brief period in the summer the weather is rarely too hot for comfort. The majority of ostrich farmers are Dutch or of Dutch descent, who naturally prefer country life and open spaces.

When the feather business was at its height farmers gave practically no attention to crops other than the lucerne and mealies that were essential ostrich foods. Even the vegetables required for home consumption were purchased by many ostrich farmers.

As buck and small deer and game birds are found on many of the farms, shooting parties are of comparatively frequent occurrence. This, with his occasional trips to town and interchange of visits with friends, constitutes the usual recreation of the South African ostrich farmer. His home is usually comfortable and frequently quite imposing. Motor-cars are very commonly used in most farming sections.

During the mating season ostriches are decidedly dangerous, attacking a man without hesitation. One kick from the bird's foot is usually sufficient to put any ordinary individual out of action, and several deaths from this cause have been reported. During the nesting period the male and female sit upon the eggs alternately. Broods of eight to fifteen chicks are usual from a sitting of sixteen or eighteen eggs. Incubators are also much used. Ostriches are fed upon alfalfa and mealies, but they pick up a good proportion of their food on the veldt.

On full-grown birds feathers are generally classified as wings, tails, and body feathers. These general classes are graded into numerous varieties to which different names are given. The best long white plumes from the wing of the male bird are termed whites or primes. The latter term is particularly applicable to the best quality whites. Similar feathers from the female are termed feminas; these are white plumes like those from the male, but are usually smaller and generally inferior.

The top row of wing feathers consists of wing blacks or plumes, which are white and black on males and white and grey on females. These are termed byocks or fancies. The second row consists of the whites, or primes, previously mentioned, and are the finest produced. The third row feathers on males are called long blacks, and on females grey. Feathers from under the wing are called floss; body feathers, blacks and drabs or drabby-greys; and the tail feathers are called tails or boos.

There have been previous slumps in ostrich feather prices, but none so serious or so long continued as the present one. Traders admit that the outlook is anything but encouraging. Nevertheless the ostrich feather will come back; it is too beautiful to be long neglected.

THE DEVELOPMENT OF THE TEXTILE INDUSTRIES.

The Fresh Start.—In one stage of the evolution of a textile industry producers manufacture nothing beyond the plainest of plain cloths, easy to make and certain of sale. The repetition continues until it becomes irksome, when one of more

enterprise than his neighbours ventures upon a line of simple fancy goods, and these serve until they grow stale and are replaced in favour by articles of more novelty. The pace gradually quickens until the pursuit of novelty develops into a race, and the total bulk of the production divides itself into a business in relatively large quantities of the plainer goods upon the one hand, and a more precarious trade in elaborate and expensive cloths, made in an increasing number of patterns, upon the other. During the war the process has been reversed, and industry has been returning, in this respect at least, to the days of its infancy. Textiles have grown plainer, and their range of variety has been reduced to a point beyond which it is almost impossible to get. Starved as the markets are in point of quantity, they may remain for a long while thankful for what they can secure without too nice regard for art or excellence, but sooner or later exfoliation must be renewed. A virtually fresh start has to be made, and it can be submitted that the time and circumstances give an unparalleled opportunity for the direction of taste into right channels. Fashion was never so capable of being moulded, and it is impossible to foresee when any movement for the advancement of industrial art will find so clear a field.

Trade Organisation.—Sir William Priestley, in reference to the Bradford textile trade, recognised within it two sections: the bread-and-butter business on which manufacturers could live but not prosper, and the trade in specialities out of which profits could be made, but the whole community could not be employed. Most manufacturers prefer to retain an interest in both classes, so securing their own position in the event of disappointment. The policy is the mature fruit of seventy years' experience, and Sir William Priestley and others are irked by suggestions that they do not know their interest, and that the future lies with the production of unlimited quantities of common articles. The truth is that large-scale production cannot continue without setting up demand for less vulgarised patterns. The Textile Institute is quite the proper place for a protest against a too mechanical a view of an industry which offers a myriad opportunities to those who are clever enough to seize them. The brutalising influences of factory production are certainly not to be relieved by mere enlargements of scale and the flattening-out of factory products to a uniform mediocrity of style. In a general way what British textile industry wants is more lightness and brightness, greater intellectual agility and scope for individuality. The problem is not one of how to become more like America, or Japan, or Germany—as seems erroneously to be supposed —but rather of how to endue our solid virtues with the sprightliness of France.

Wearing Tests.—Tensile tests are the accepted ones in judging of the capacity of a cloth to resist hard wear, although they manifestly do not tell the whole story. Cloths in use are exposed to other strains than those of a steady pull, and it does not follow absolutely that the fabric showing the highest breaking strain is actually the best wearing. One merit of the test is that at least its results can be recorded with fair accuracy, and it does not appear that this would be possible with the apparatus described as in use by an American clothier. The aim is to reproduce normal conditions of attrition, and for this purpose a surface such as a chair-bottom is taken as a foundation. A specimen of the cloth is stretched over a slightly elastic cushion, and weights are imposed calculated in reference to the area of surface and the normal weight of a man. Eccentric rods give the sample a sliding and rubbing motion, and an indicator records the number of revolutions of the driving shaft. Samples submitted to an equal number of revolutions are then compared with one another, and it is, of course, found that comparative merit does not follow strictly the order of prices. What would be more interesting to know is whether experience gained under these conditions agrees with the judgment formed by moderately expert observers using their unaided senses. Shrewd ideas can be formed from a brief examination of the fibre, the twist of the yarn, and the structure of the fabric. So many factors are present in determining the choice between one article and another that any test restricted to discovery of one feature has necessarily a limited utility in practice. A more ambitious and prospectively more useful device is foreshadowed in the *Textile World Journal* of New York. The writer is busy upon an experimental machine for giving cotton cloths dry friction, representing their treatment in use, and for rubbing them in a wet state, brushing, drying, and ironing them as in laundering. Here again admitted difficulties are met in reproducing all the regular conditions of the washing and drying processes. As irregular conditions, such, for example, as the development of mildew, have to be allowed for, not even such a machine can be relied on to meet all needs.

Aeroplane Cloth.—A sidelight is thrown upon military preparations by the news that 11½ million yards of aeroplane cloth have been let on contract in America by the United States Government, and that deliveries average about 1¼ million yards per month, although the production only began in January last. The cloth is a cotton one, made with long Sea Island fibre, and of a minimum strength of 80 lb. per inch in warp and weft directions. Linen has been superseded in American practice both for practice and combat machines, and the official standard cloth has earned good reports at home and abroad. Joined to the large British production of wing fabric, it is apparent that a great new trade has sprung up, and conceivably one which will not end with the war. The tyre cloth business is present as a reminder

of what changes in modes of travelling may do, and aeroplanes do not need to become as common as motor-cars in order to provide a considerable market for cloth. Cotton, it will be observed, comes unfailingly into direct association with each new development of the times.

GENERAL NOTES.

INDIGO IN THE BOMBAY PRESIDENCY.—Previous to the Indian famine of 1900 some 200 acres of land in the Jambusar taluka, Gujarat, were devoted to the cultivation of indigo. According to a correspondent of the *Times of India*, the local cultivators made a fresh start last year with about thirty acres. "The Surat, Broach, and Kaira districts in Gujarat are," he says, "eminently suited to the cultivation of indigo, and if serious attempts are made in these districts and in the Baroda State to popularise the raising of the indigo-bearing plant, the obsolescent industry will prove entirely successful on a commercial scale in the course of the next few years." It is added that the Bombay Agricultural Department has for some time past encouraged indigo production in the Khandesh and Broach districts. Mr. William Foster, C.I.E., in his paper, "English Commerce with India, 1608-1658" (*Journal of the Royal Society of Arts*, Vol. LXVI. pp. 361-372), mentions that in 1615 the "Hope" took home from Surat, once "the chief export and import centre of India," over 1,400 bales of indigo, and that thenceforward this article became the principal constituent of the cargoes shipped to England from the same emporium. The chief centres of supply were Sarkhej, near Ahmadabad, and Biana, near Agra. In 1652, the Surat factors wrote to the East India Company that "indigo hath heretofore bin your most gainefull comodity."

BRANDED HIDES.—In a paper on the leather trade read before the Coimbatore Agricultural Conference, the author, Captain A. Guthrie, said branding is done in India chiefly for identification, medical and ceremonial purposes, to avert the evil eye, and to render the hide valueless, so as to stop any chance of the animal being poisoned for the sake of its skin. For identification purposes a small brand on the cheek or neck would be effective. He very much doubted if heavy branding stops poisoning, and the value of branding for the other reasons mentioned was also to his mind very doubtful. Indian hides are often very much damaged by carelessness in taking the hides off the carcass. In the case of a sample shown the value had been reduced from Rs. 21 to Rs. 9-8 by flesh cuts. Something like 50,000 branded hides per month came into Madras, averaging a damage of Rs. 4 per hide, so that the monthly loss came to Rs. 2 lakhs. This had reference only to hides good enough to be purchased by the Government. Most of the more badly branded hides do not come in at all, so that the total damage must be much over Rs. 2 lakhs per mensem. The Governor of Madras (Lord Pentland), speaking in the discussion on the paper, said that the real loss was Rs. 3¼ lakhs per mensem. The Agricultural Department had issued bulletins which he hoped would convince owners of cattle of the need for refraining from doing such damage to the hides.

MATERIAL RESOURCES OF BURMA.—Writing in the *Bulletin* of the Imperial Institute, Sir Harvey Adamson, K.C.S.I., lately Lieutenant-Governor of Burma, shows that the material resources of that province are both numerous and valuable. But, while the province has a fertile soil, a rainfall which has never been known to fail, abundant fisheries, magnificent forests, and great though almost unexplored mineral wealth, only three products—rice, teak, and mineral oil—have yet attracted British capital on a large scale. Sir Harvey Adamson attributes this to the comparatively small population, whereby labour is twice as dear as in continental India, and to the inadequate communications; and he advocates a more generous financial policy for the equipment of Burma with roads and railways and other needed public works. Private capital, as well as public funds, can find profitable employment in developing the resources of the country. Sir Harvey Adamson denies that Government is opposed to private enterprise. In the interest of the taxpayer, Government is bound to reserve for itself a fair share of the profits from the exploitation of natural products; but it is always ready to welcome *bonâ fide* applications for concessions from experts or capitalists.

BRAZILIAN PITEIRA FIBRE.—Much has been written concerning the possibility of Brazil developing a large industry in the exploitation of its vegetable fibres. One of the most promising of these fibres appears to be that of the piteira or *Fourcroya gigantea*, because of its adaptability to the making of sacks for bagging coffee. Tests recently made in São Paulo, writes the United States Consul-General at Rio de Janeiro, are said to have been very favourable, and to have shown that the fibre can be used as material for spinning and weaving. It appears to be similar to Manila hemp, both in elasticity and resistance. Potash and wood alcohol are stated to be by-products. Among the various reasons given why this fibre should be produced on a commercial scale are the following: The plant is a native of Brazil, and is adapted to the soil and climate. It lasts from eight to sixteen years, requiring very little cultural attention. From 2 to 3 per cent. of the weight of its leaves is said to consist of fibre, and it gives a considerable amount of alcohol. The piteira may be successfully grown in poor soil. In other words, it is a plant which grows practically unattended in soil of no particular agricultural value.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, at the Society's House, John Street, Adelphi, London, W.C. (2)

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PROCEEDINGS OF THE SOCIETY.

PROMOTION OF INDUSTRIAL ART.

A meeting was held at the Royal Society of Arts on Monday, October 28th, the RIGHT HON. H. A. L. FISHER, M.P., President of the Board of Education, in the chair.

[The meeting was originally called to consider a Scheme for the Promotion of Industrial Art, which had been formulated by the Industrial Art Committee of the Royal Society of Arts. After the invitations had been issued, it was found that considerable confusion existed in the public mind as to the claims of this scheme and the Board of Trade proposal to institute a British Institute of Industrial Art. Although the two schemes originated quite independently of each other, it soon became evident that they are really complementary, and it had always been intended that they should work together in close co-operation. To make this clear it was decided to submit both schemes to the meeting, and to issue a joint appeal for subscriptions.

The two schemes will be found printed as Appendices to this report.]

THE CHAIRMAN, in opening the meeting, said: My Lords, Ladies and Gentlemen, we are met here to-day to promote two schemes for the furtherance of industrial art in this country, and although I am neither an artist nor a manufacturer, nor concerned with the distribution of artistic wares, the interests of education and the interests of industrial art are so closely intertwined that I make no apology for taking the chair upon this occasion. The project which we desire to promote to-day is a project which has the support of the Board of Education, of the Board of Trade, and of the Royal Society of Arts, and we propose to issue a joint appeal to the public in support of two schemes which we believe to be conceived in the best interests of industrial art in this country.

Now, the State is by no means indifferent to the progress of the arts and crafts. Already it expends a considerable sum of money upon technical schools, art schools and museums, and it therefore is vitally concerned to see that this public money is wisely and effectively expended. If we ask ourselves the question whether we are at present satisfied that everything which can be done to promote British industrial art is being done, I think we must certainly answer that question in the negative. I think everybody would admit that much more might be done than is done; that much more encouragement might be given to our craftsmen working in isolation and scattered over different parts of the country; that our training in industrial art is susceptible of great improvement; and that much might yet be done to bring the world of industry and the world of art into a closer and more fruitful connection. For we are an artistic people. We are very fond of depreciating our own capacities, and especially of depreciating our own attitude and genius for the fine arts; but I venture to say there has not been a single generation in the whole course of recorded history in which this country has not given indications of its aptitude for artistic productions. The miniatures and the illuminations of this country in the Middle Ages are, if we take the best period, as good as any which have been produced anywhere in Europe. I venture to think that the needlework of this country was better than the needlework of any other country in the Middle Ages; and, even if we make exception of our glorious dynasty of national painters, there has not been a single generation in this country in which we have not shown our capacity for finished accomplishment in the arts and crafts. Although it is perfectly true that since the death of William Morris we have had no supreme master of the arts and crafts, although it is perfectly true that we have perhaps lived too much upon the capital of William Morris's genius, still I think every competent observer knows that this country is rich in craftsmen and rich in designers, and that we have within us the capacity, if that capacity has adequate opportunity, to show the world that we yield to none in the industrial arts and crafts.

The chief purpose of this meeting is to lift our national industries on to an altogether higher level of artistic achievement, by affording encouragement to our designers to obtain first-hand acquaintance with the medium in which they work, and by the formation of a permanent

Exhibition of British Industrial Art, which shall not only offer a stimulus to our craftsmen and designers, but also enable us to obtain a conspectus of the state of contemporary art at any given period of time. One of the schemes before us to-day is a scheme for the establishment of a British Institute of Industrial Art. The Board of Trade, in conjunction with the Board of Education, and with the advice of representative members of the Royal Society of Arts, the Arts and Crafts Exhibition Society, the Art Workers' Guild, the Design and Industries Association, and various persons and organisations connected with manufacture and commerce, have framed a scheme for a British Institute of Industrial Art, and it is proposed that this Institute should be incorporated under the joint auspices of the Board of Trade, as the Department dealing with industry, and of the Board of Education, as the authority controlling the Victoria and Albert Museum. The methods by which it is proposed that our object should be achieved are first of all the establishment of a permanent Exhibition in London of modern British works selected as reaching a high standard of artistic craftsmanship and manufacture. I lay stress upon the phrase "high standard of artistic craftsmanship and manufacture," because, if this enterprise is to succeed, everything depends upon the maintenance of a high standard. Everything depends upon the formation of a jury of selection which shall be stern, censorious, and competent, which will rigidly reject inferior work, and hold up before itself a very high standard of achievement as qualifying for a place in the Exhibition. If this condition is to be realised, if the selection is really to be competent and stern, then it is necessary that there should be a financial guarantee. It is necessary that the jury of selection shall not be subject to anxiety as to balancing its accounts; that it shall not be compelled, through financial need, to accept the offers of firms desirous of obtaining an advertisement of their goods, and willing to pay a handsome price for that advertisement. It is therefore an essential part of our proposal that funds shall be subscribed sufficient to place the Exhibition out of the reach of financial difficulties—at any rate, in the first years of the experiment. In time, no doubt, the Exhibition will pay its way.

In the second place, it is proposed that a selling agency should be attached to the Exhibition, and I think it will be clear to my audience that that proposal is likely to enlist the interests of a great number of manufacturers and industrial producers in this country who might otherwise feel less anxious to exhibit specimens of their artistic products in a London Exhibition. Thirdly, it is proposed that there should be a purchase fund for securing for the State selected works of outstanding merit exhibited at the Institute; and just as the State every year makes certain purchases from the pictures exhibited in the Royal Academy —perhaps not always very judiciously—so it is proposed that certain works of outstanding merit should be purchased by the State from this Exhibition of Industrial Art, and that those works should be placed in the Victoria and Albert Museum. Now, as you are aware, the Victoria and Albert Museum is a wonderful collection of the arts and crafts, not of the present age, but of preceding ages in human history; and I think you will agree that the value of that collection as an educational force in this country, as an active, vital, energising influence over the contemporary arts and crafts, will be very greatly increased if there are placed in the Victoria and Albert Museum specimens of the best contemporary craftsmanship.

It is also proposed that machinery should be established for bringing designers and art workers into closer touch with manufacturers, distributors, and others. I am aware that I am speaking to an audience very much more expert in this matter than I can pretend to be, but I have some reason for thinking that the manufacturers of this country are not quite so alert as are the manufacturers in France to embark upon new artistic designs; and it very frequently happens that quite beautiful and original designs which are presented to English manufacturers are viewed with a considerable amount of suspicion, and that our manufacturers are unwilling to take the artistic risks which are much more freely taken by our brilliant Allies, the French. Of course, part of this may be due to the conservative national temperament, or perhaps to the weak business acumen of our fellow-countrymen, but I think part of it may be due to another cause. I think it is common knowledge that many of our designers, admirable as may be their grasp of the principles of draughtsmanship, are not sufficiently versed in the qualities of the material to which their designs are to be applied, and that it frequently happens—I know this is the case in the textile trade—that a design which looks admirable upon paper, loses, like a translation from Homer, when it is proposed that it shall be transferred to the looms, and that it has, so to speak, to be redraughted and readjusted to the material conditions to which it was originally intended to be applied. The knowledge that many designs good enough on paper are not really suited to the genius and quality of the material for which they are intended, acts as a barrier between the manufacturer on the one hand and the artist on the other, and renders our manufacturers less willing to accept the imaginative creations of the designing world. I take it that it is part of the project of the Royal Society of Arts to encourage, by means of scholarships, and prizes among art students who are taking up this branch of art, a closer and more practical knowledge of the medium with which their art is concerned. After all, it is an impossibility to divorce form and matter in the plastic arts, as it is impossible to divorce form and matter in poetry. Every great and supreme artist has had an intimate and affectionate acquaintance with the qualities and possibilities of the material out of which his art grows.

Among the means which we contemplate for improving artistic education is a closer association with the British School in Rome. This School, which was founded for the study of Roman archæology is, I understand, about to be expanded, and it will become a great institute for the assistance of scholars, students, and artists desiring to make an acquaintance with the artistic legacies of ancient Rome; and arrangements will be made between the British Institute of Industrial Art and the British School in Rome to facilitate Roman studies among English craftsmen and artists.

One word more before I sit down. Although it is true that two Government Departments and one private Society — the Royal Society of Arts — are concerned in this scheme, and are making this appeal to the public, I wish it to be understood that the appeal which we are making is a joint one. It is a joint appeal on behalf of the Industrial Institute on the one hand and of the Royal Society of Arts scheme on the other. The two Government Departments under whose patronage the scheme is to be founded have an equal interest with the Royal Society of Arts in the furtherance of British industrial art, and it is, I think the happiest augury for the success of this enterprise that we have gathered here to-day so many leaders of industry on the one hand and of the arts and crafts on the other.

LORD LEVERHULME: All those who have most deeply at heart the success of the movement that has been inaugurated to-day are to be congratulated upon the presence of Mr. Fisher with us at the meeting, and upon the clear and lucid statement which he has given of the underlying principles which must be borne in mind in endeavouring to make a success of the objects we have in view. We are also grateful to him for calling attention to the fact that we are an artistic nation. No one can dispute the inherent soundness of the British taste for art. I was amused recently at reading a report, dealing mainly with canned fish, made on behalf of a foreign Government, because it was there stated that as soon as the fish-curers and canners paid more attention to artistic labels and designs, wonderful progress was made in the foreign markets. The gentleman who was responsible for that advance was an Englishman, a friend of my own. We are not the backward nation that we are often said to be. Another friend of mine, Mr. Waring, was, as you probably know, commissioned by the Kaiser to furnish his yacht, not in the German taste, but under definite instructions from the Kaiser that the furnishings should be in the British taste of the eighteenth century. The object of the Kaiser, which he so boldly put into effect, was to show those who had the furnishing and the fitting of the great Germanic Atlantic Ocean steamers that we English in domestic taste were ahead of the German race. I am perfectly certain we shall all be agreed that of all styles of decoration the one in which a lady always looks most the lady and a man always looks most the gentleman is the English style of the eighteenth century. Therefore we do start in any campaign of this kind with the right material to work upon, and there must always be an excellent basis for any advance that we are prepared to make.

People who are much immersed in all the details of business are apt to overlook such details as the labels on their packages and even their notepaper and billheads. After all, these are only a connecting link between the producer and the consumer, and surely it is perfectly legitimate to create a favourable impression upon the consumer by means of an artistic, properly designed label, by the best artists of the day, before the package is opened and the quality of the contents can be examined. Any carelessness in this respect on the part of British manufacturers in the past has placed a very heavy and severe penalty upon them. Sometimes the notepaper and billheads are too ornate, containing pictures of medals and so on that have been won at various shows, and these can only create a rather cheap impression. Sometimes they are not only very plain, but poorly printed, so that again a bad impression is created. Therefore the connection of good design—in other words, art—with the question of presenting the goods of the British nation to the great outside world is one that deserves and ought to receive the very closest attention.

When this war is over, we shall have many tasks, and amongst them will be the making of money available for taxation to pay off our war indebtedness. Although those who took a keen interest in the close connection between art and science were in a minority before the war began, when the deluge of the war is over I am certain that they will be in a majority, and that we shall all see the immense value of art and science in developing the resources of the Empire. It will also have an effect in improving the temperament of our workers. Surely it is not a fact that we can be proud of that we have to acknowledge that the mentality of many of our Trade Unionists in this country is such that an Englishman—the finest material the world has produced, who is welcomed as a tradesman, either as an engineer or a carpenter, or whatever it may be, in every country in the world—should be standing, say, on the landing-stage at Liverpool, worth only half the wages that the same man will be worth in a week or ten days' time if he steps on board a boat bound for New York. Now, there must be a reason for this, and surely it will be within the scope of an organisation such as we propose, to raise the mental outlook of our workers so that they see the true reason for it. The reason is this—we have an illustration of it at this very moment close to Liverpool, at Aintree, where a dispute has arisen upon the question of a bonus on output to the workmen—that the outlook of our workmen here in England is limited to narrow confines

bounded by restrictions on output, commonly called "ca' canny," an entirely false view which science and the science of production ought to remove. Suppose an English workman lands in New York, and is engaged by a great engineering firm: if he were to promulgate the doctrines that he had learned from his Union in Liverpool as to restriction of output, he would receive no sympathy from the men across the Atlantic. He would find the Trade Union officials, with Mr. Gompers at their head, repudiating his doctrine as out of date, obsolete, and unscientific. His output would be increased. Instead of being restricted to the use of one automatic lathe, as he would be in England, there would be placed at his disposal as many automatic lathes as he could look after to produce the right quality of goods—perhaps five, six or seven; and instead of receiving, say, the 10*s.* a day that he had been receiving in England, he would receive £1 a day in America. In the one case his output would be costing his employer 10*s.* per machine per day, and in the other case perhaps 4*s.* per machine per day. What wonder is it, then, that, with this false outlook on life, the makers of motor-cars, for instance, in England are outclassed entirely in competition with the makers of motor-cars in America who pay the same workman double wages? And that is the case; it is taking place to-day in the United Kingdom.

I do not want us to feel that this is merely a matter of art in design. It must be art that will broaden the worker's outlook, that will give him something more than a limited view of life, and make him see something in his art which the painter sees in producing his picture. The painter who produces a picture merely with the idea of what the picture will make is, as you all know, a pot-boiler, and he fails to achieve in a very short time even the narrow limited objects he had set before him as his ideal. Similarly in regard to our handicrafts: we must teach our workman to take a pride in his output and production, and, if that were done, the policy of "ca' canny," no matter whether dictated by himself or by his Union, would disappear as morning mists before the rising sun. We have an immense field in this direction. I feel confident that there never was a time when the Empire so needed such guidance as can be given at the present moment, when there are such lessons that it is within its power to learn by means of travelling scholarships, which I am glad to see are part of the scheme, and by close contact between minds that are taking a broader outlook on affairs in general. Let us remember that in all this work we are laying the only solid foundation for reconstruction after the war. Any cheap attempt at doing our business on shallow lines wlll be entirely unsuited for the circumstances of the case when this war is over. We shall start with a handicap, in all probability, of six or seven thousand millions of debt, the interest alone upon which will be a load greater than many people in this room imagined before the war that this country was capable of bearing, apart altogether from the other expenses of Government. We know that it is only by the application of the highest skill and technical knowledge that the best results can be obtained. The progress of evolution will be the same. In the old days poor results were obtained by men who paddled canoes; better results were obtained by the men who first erected a stick on a boat, with a leaf or a palm to act as a sail; later on, better results still were obtained by the men who put in a primitive engine, until we come down to modern times, when the finest results of all have been obtained in our modern Atlantic greyhounds with their turbine engines. The progress that has been made through the centuries has only been possible by the application of the highest knowledge and ability to the utility and the service of man. What the progress may be in the future none of us can realise, but there is in the great wide world the British Empire teeming with wealth only asking to be developed. It cannot be developed by unskilled labour; it cannot be developed without the right tools and the right men, and all this can only be achieved if we train ourselves and others rightly for the task. The London County Council, at the Central School of Arts and Crafts, are making one great advance in training for the art of salesmanship by giving the salesmen and the saleswomen a knowledge of the goods that they have to handle. That is only a beginning. In all other branches we want equally expert knowledge, and with this knowledge and such help as can be given by this organisation I do not think we need be appalled at all by the load of the national debt. Debt is the greatest stimulus you can apply to a human being of the right kind, because there is a natural instinct in the right-thinking mind to clear itself of debt. The existence of a mortgage put upon a home to complete the building or to complete the purchase has probably been a greater stimulus than anything else at a certain period of a young man's life; and I believe that this debt, great as it is, if faced in the right way, with the people of the country trained and developed by such organisations as we are met here to promote, will only be a blessing in disguise. I have very great pleasure in supporting all that Mr. Fisher has said.

Sir Frank Warner, K.B.E.: Although I am deeply interested in both the schemes intended to promote the welfare of British Industrial Art which we have been called together to consider this afternoon, my allotted task is to speak on the British Institute of Industrial Art which it is proposed to establish, and I shall therefore confine my remarks entirely to some aspects of that subject.

At the outset I should like to say that while there is a widespread and natural desire to eliminate Government control of industry at the earliest possible moment, there is at the same time a realisation that the State has functions in connection with industrial development which can be exercised with great advantage. The formation of

the British Institute of Industrial Art is, it appears to me, an excellent example of the part which the Government should play in the promotion and extension of British trade.

It is unnecessary, particularly before such an audience as this, to go at any length into the history of the great improvement in the artistic merit of many of the productions of this country, as that improvement is universally acknowledged; but I may at least be permitted to remind you of the events which in recent years have acted as landmarks in that history.

On the side of artistic manufacture as distinguished from artistic handicraft, the International Exhibitions at Brussels in 1910 and at Turin in 1911 demonstrated beyond dispute that in many branches of industry, particularly in British furniture and decorative art, in pottery and in many kinds of decorative textiles, such as tapestries, silk brocades and velvets, printed linens and cottons, we had made a marked advance in design and colouring, and were, with the exception of France, in certain respects, ahead of all other countries in artistic merit.

At the Ghent Exhibition of 1913 a considerable space was set aside for a display of British Arts and Crafts, and this was so admirably filled and created so much favourable comment that a desire was expressed by the French that it should be repeated in Paris. A portion of the galleries of the Palais du Louvre was cleared for the purpose, and in April, 1914, that ever-memorable exhibition, the contents of which still remain there stored in the cellars, was opened by our King and Queen.

The remarkable interest created and the wide success achieved by these exhibitions led Sir Hubert Llewellyn Smith, Permanent Secretary of the Board of Trade, and Sir Cecil Harcourt Smith, Director of the Victoria and Albert Museum, to write memoranda in which each, without any knowledge of what the other had done, arrived at practically the same conclusion, viz., that there should be established in London, as the capital of the Empire, a permanent Exhibition of Works of Modern British Decorative Artists. These two gentlemen are therefore the originators of the idea, and to them most of the credit is due for the admirable scheme, which I will call the Government scheme, placed before you to-day.

Sir H. Ll. Smith in his memorandum very truly says that "the greatest present need of industrial art in this country is not so much the training of additional artist craftsmen, but the improved organisation of the market for artistic products and the increased appreciation of such products by the public." To-day I am sure he would have gone further and added that it was the "increased opportunity" for such appreciation that was needed, for that is really what the Institute is intended to provide. He also said: "It is notorious that a large proportion of artistic craftsmen have little faculty for commercial organisation; they are scattered and isolated, and liable to be altogether outclassed by the big trading concerns which command the market by reason of their business organisation and commercial enterprise. On the other hand, the purchasing public have little idea of a standard of artistic production, and still less the means of knowing where to lay their hands on the producers of the best artistic work in any particular line. What is needed is an organisation intermediary between the individual craftsmen and the public. This should take the shape of a permanent central exhibition of current works produced by living craftsmen, for sale, subject to the enforcement of a high standard of merit by a selecting committee. Such inquiries as have been made indicate that on the part of artist craftsmen there is a great and growing demand for such an organisation."

It is clear, in my opinion, that if such an organisation were provided, it would not only meet a long-felt and very real want on the part of artist craftsmen and that small section of the public which appreciates their productions, but it would act as a powerful stimulus to the development of the artistic creativeness of our people, and to the fanning into activity of that artistic flame which I am positive is smouldering to a far greater extent than is commonly believed, and which only lacks the necessary atmosphere of encouragement to burn brightly. The Institute would not merely do this, but also provide what I am sure everyone is agreed is much needed—the means of educating public taste and of guiding it on the right lines. This will be an important branch of its work which will find a wide field for its usefulness in provincial centres, as well as in London, as it is obvious that the appreciation of, and the desire for, good things must go hand in hand with the creation of them.

And now I come to the question of the products of the manufacturer, of the firm producing, not the unit by hand, but the thousand by machinery. The manufacturer already has his market, and most of his products are available to the public in the shops, but he is restricted, from an economic standpoint, to those productions which the merchant or distributor will select, and these in turn are guided in their choice by what they believe the public will buy. At times the manufacturer aims at something higher, and produces, frequently at great cost, an article which is different from, and in his opinion better than, the normal marketable article, but he finds in many instances no sale for it. The market to which he is confined may even go so far as to admire it, but will not touch it because the public is not educated up to it.

There are few manufacturers of articles where design or colour, or both, are essentials who have not had their period of enterprise in original or improved production, and have not met with this rebuff. A desire to do something out of the ordinary, to help perhaps some struggling designer of merit, some ambition running riot, or whatever may have been the impulse, has usually resulted in loss and disappointment. Then a definite resolution is made never to attempt anything outside

the boundary of trade requirements; enterprise is quashed; the designer of something possessing original merit is turned down, and a rigid cold shoulder turned to everything likely to be progressive in an artistic sense. Now, this is a condition of things the Institute will do much to remedy. The manufacturer will have a court of appeal before whom he can place his exceptional production. If it is rejected, there is the end of it; if it is accepted by the selection committee, the "cachet" attached to its inclusion in the exhibits of the Institute will alone be a great encouragement, the public will at least see it, and it is more than probable that in most cases the enterprise of the manufacturer will prove to be a success instead of a failure.

There need be no apprehension on the part of wholesale and retail distributors that they will be in any sense supplanted, as it is proposed, in regard to trade productions, that the selling activities shall be conducted on the lines of the British Industries Fair, and certain days will be set apart for accredited trade representatives to meet manufacturers for the purpose of transacting business.

The purchase fund which it is hoped will be provided by the Treasury for securing selected works of outstanding merit for the State is, in my opinion, a most valuable feature of the Institute. Hitherto the best work of a living artist has been allowed to become scattered; some of it passes into private collections, some goes abroad, and the trace of some is entirely lost. When half a century has elapsed, an attempt is made to recover some of these works for our national museums, with the result that the best is either unobtainable or is only purchasable at a price many times greater than its original value. The purchase of such works by the Institute will also form the nucleus of its collection, and in due course these specimens of the best production of an admittedly eminent creator of artistic objects will pass into the keeping of our great national museum for preservation and as examples for the education of future generations.

Hitherto, as is well known, the Victoria and Albert Museum has not been able—owing to want of space—to deal adequately with modern productions of industrial art. It has therefore sometimes been subjected to criticism as an institution dissociated from the life and interests of to-day. The proposed Institute will, it is hoped, establish the essential continuity and remove all ground for such reproach.

The usefulness of the Institute will not end with the opportunities it will bring to craftsmen and manufacturers to extend their activities, nor with the securing of objects of outstanding merit by the State. It will possess and exercise a most important function in bringing designers and art workers into closer touch with manufacturers, distributors, and others who can give them opportunities, which they at present lack, of using their talents to the best advantage. The manufacturer needs people with original ideas and artistic taste; the industrial artist needs the opportunity of putting his activities to practical and profitable use. If the Institute can bring the two together, it will in this respect alone more than have justified its existence.

The opportunity, in view of all that is happening, is for all of us unique and full of great possibilities. Our one outstanding hope of salvation financially is the development of industry on economic and artistic lines. The schemes placed before you to-day concentrate on these vital points. I trust they will be widely approved of and receive your most generous support.

Sir William M'Cormick, LL.D. (Administrative Chairman, Advisory Council, Department of Scientific and Industrial Research): I have been asked to say something as to the relation of this movement to the Department with which I am at present connected—the Department of Scientific and Industrial Research. That Department originated, as most of you know, more than three years ago, in just such a movement as we see at present in relation to art. It was felt that we should pay more attention to the application of science to industry, and that we were not developing on scientific lines as fast as others were, partly perhaps owing to our own fault, and partly owing to the conditions of manufactures and manufacturing in this country. We are all feeling the same now with regard to art, and it occurs to me that I might tell you one or two points of our experience which may be of use in connection with this movement. The first problem we had was to bring the scientific man into connection with the industries. I ought perhaps not to say "the scientific man," because the industrial man is as good a scientific man as what we call the scientific man. We are apt to confine science merely to physics and chemistry, whereas there is also a science of business, a science of costing and of manufacture. But the difficulty was to bring the laboratory into touch with the factory, and the solution we found was to bring the scientific man out of his laboratory and put him into the factory. I was delighted to hear that that was Mr. Fisher's solution to-day with regard to art. Art is not a thing in itself; art is conditioned entirely by its materials, and its technique depends upon these. It is no good taking an artist out of a studio to make a design for some textile such as silk or cotton. He does not know anything about it. He can produce what he thinks is a very pretty design on paper, but he does not know anything of the application of either colour or form to the textile industry. We want to-day to bring the artist out of his studio and put him beside the loom or into the silversmith's shop, where he will learn to understand the material in which he is going to design. It is not merely a matter of the modification of designs that have been made on paper by someone who did not understand the subject; they should never have needed any modification. A design that needs modification is not a true design. It must be a design that

comes out of the brain of the worker who is familiar with the loom and the shop. That should be our central idea in all science.

There is one point which is a corollary of that, namely, that if the movement is to be a success, the initiative for it must come from the industries themselves. We tried to secure that in our scientific movement, and I think in some respects we are hopeful of success. We have had interviews with representatives of thirty to thirty-five of the great industries of Britain, and about half a dozen research associations of the firms engaged in particular industries have already been formed. In connection with those research associations, councils are set up with governing bodies and a director. Not only science and the application of science to the particular industry concerned have been included in their functions, but education also; and there is no reason why these councils that have been formed in the industries for the scientific and educational development of those industries should not also include their artistic development. I think that might quite well be combined with the movement which we have already originated. Might I just give two instances of how closely we are related? The very first research that our Department assisted in was a research in connection with the national pottery trade, and the result of the assistance which we gave them three years ago is that the gentlemen who are engaged upon the research believe that at last they have found the possibility of our making hard porcelain out of British material—a thing that will, if it is workable, probably revolutionise the whole pottery trade of Staffordshire. But the curious thing is this. Probably most of you know that the body in porcelain is the soft clay of which it is made. Now, the body of the new base for this hard porcelain will not stand moulding into the same shapes as those for which china clay is at present used, nor will it take the same colours; so that here you have a new material for industry which you cannot make use of until you bring in the artist as well as the scientist.

Then there is another instance that I should like to mention. We have been asked, in connection with the urgent need for the building of houses immediately after the war, to go into the whole question of the materials, to try if we can find, above all, materials other than wood and bricks — possibly to find through science a means of returning to the old method of cob-building, using the soil on the spot where the house is to be built, with possibly some chemical infusion, and so on. If something like that is found, the whole art of house-building will be conditioned by that material. I do not mean that we are going to build "Art" homes with a capital "A." I was speaking about this the other day to Sir Edwin Lutyens, and he hoped we should not do that, because there is a very grave danger that we may begin to think with a capital "A," and then put "Fine" in front of that letter. I take it that what we are here for to-day is to advance the art of our simple and common every-day life. But that leads to one great difficulty to which Sir Frank Warner has already referred. It is easy, so long as you keep the handicraft, to make experiments in art. The single craftsman tries a thing; he does not succeed; there is no great loss. But experiments in manufacture by the thousand and hundred thousand with our present machinery are another matter. That was really the reason why we asked all the firms in various British industries to combine together. We had the same difficulty in regard to science. The transference of new scientific machinery or a new scientific process from the laboratory to the factory is a very serious and expensive matter. It might not work; it might not be economical: and the same applies to art. As Sir Frank Warner says, a single manufacturer cannot stand the loss of making continual experiments that do not come off. He cannot afford to make hundreds and thousands of art experiments and to have a succession of failures. I suggest that this might be done by the same research associations of which I have spoken, and that they should make the experiments for the good of the industry as a whole. If that were done, your Exhibition and your whole scheme as set forward would admirably adapt itself to such developments as I have indicated.

Sir Charles Allom: In the first place I should like to draw attention to the encouragement which I am sure we have all derived from such a gathering as this. I should think that in the history of industrial art there has never been such a gathering of those who are at the top of the tree in every branch of it. I desire also to thank Sir William M'Cormick on behalf of this Society for the magnificent offer he has made on behalf of the Institution to which he belongs, namely, to make experiments for us. I feel that in the process of carrying through the proposition that we have before us there will be many side issues, and it will devolve, I expect, upon the Royal Society of Arts frequently to take up those side issues and see them through. It will be impossible for any industrial arts body by itself to follow the scientific difficulties which will present themselves from time to time, and such a body as that under the charge of Sir William M'Cormick can attend to them with the greatest care, particularly as it has the greatest amount of money also at its back. The Chairman referred to the question of maintaining a high level of industrial art, and that surely will be one thing upon which we shall focus our minds. It depends in the first place upon the higher education of the artist. While we have in the past had the assistance of the Board of Trade, I feel that never was greater assistance given to us than we have received to-day by Mr. Fisher's presence here on behalf of the Board of Education. The combining of two great Government offices will give us something that we cannot possibly provide through the Royal Society of Arts or any other society which exists. During the recent Exhibitions to which

Sir Frank Warner has referred, we discovered quite definitely that it was impossible for us to run Exhibitions without Government control and help. We now have a combination of two Government Departments, and one can only hope that the education of our artists, which, while it has been the best that we could give them in the direction of their arts, has been lamentably deficient in normal education, will be improved. By that I mean that too frequently our studios have been filled with boys who have come from a class that has been unable to pay for the higher education which universities can give. There are many of us who appreciate how magnificent it would be if this Society could set to work, with the aid of Mr. Fisher, to bring about the possibility of every one of our art students having the inestimable blessings of such an education. We have in this country a Museum second to none in the world, while the art schools are spread all over the country. I know the Museum does a great work in spreading its collections within the reach of the schools of the country, but at the same time we want something more than that. We need, not only in the industrial arts but in all arts and even in architecture, the opportunities which a university training would bring to the higher development of our students. I think, also, too little value has been placed upon the commercial importance of industrial art. It is sometimes forgotten that the country which produces the finest works of art in its shops is the country which holds out an irresistible bait to the richest people in the world. We know how France has benefited from having that bait. It has drawn to Paris nearly every woman who desires to be dressed in the best possible manner. It has drawn every man who was sufficiently rich to buy the most beautiful furniture in the world. On that point I am glad to know that we are gradually attracting from the French markets to the English markets the rich patrons of the decorative arts.

The question of the decorative arts, with which I am most closely associated, reminds me of the immense field of industry that it embraces. The great supremacy of our carpet industry is not only due to the quality of the carpets made, but largely to the influence of the firms who are selling them. If we can not only improve the taste of the heads of firms and the staff that selects patterns, but also enhance the skill of those who sell, you will back up the artists that you employ. I do not lose sight of the fact that a Society like this, with the help of two great Government bodies, has the opportunity of educating public taste, and thereby lifting our artists, by the stimulus of public taste, to a much higher level than they would otherwise reach. Going back over the history of Italian art, many of you will remember what an enormous debt is due to those patrons who provided funds for the artists, enabling them to live; and it is just that development of public taste and of our artists' education that I want specially to draw attention to while Mr. Fisher is with us. All of you must have been somewhat perturbed to notice that a great statesman has recently expressed the hope that he may next year apply a luxury tax. I am extremely anxious about the application of any such tax, because how far an article is a luxury is a very debatable point; and I feel that if a luxury tax is put upon the artistic products of our works a very serious blow will be struck at the supremacy of British industries. We have had held out to us the hope that some of the products of these Exhibitions—which I cannot too devoutly hope will take place—will be housed in the Victoria and Albert Museum. For my own part I can hardly imagine that that magnificent Museum will ever have sufficient room to house the products of our various manufactories, and I should think that a special department will have to be established so that these works may filter through it; and, as time and our efforts to-day influence the evolution of our industrial arts, we shall select the best of them from that great store to go into our museums.

Mr. H. Gordon Selfridge: I desire to endorse both the schemes which this meeting has been called to discuss and those things which have been said in favour of them. To make the idea practicable, however, the consuming public, which must pay its money for better and more artistically produced articles, must be made to know what the more artistically produced articles really are. The public is the jury that settles this thing finally. All of us are more or less lazy. The man who can dispose of his product without extra effort, and without discussion on the part of his customer, is usually going to continue in the same old way and follow the line of least resistance. It is therefore, in my judgment, the duty of those who are directing thought in these islands, and in any other nation, to direct, as far as they can, the great public towards the better and the finer, and make them realise what really constitutes the better and the finer. A permanent exhibition is, no doubt, an admirable thing, but I do not think it is going to create necessarily in itself more artistic products in this Empire. Really, competition within these islands is a very easy affair. I speak with the utmost goodwill—but things come so easily in England, because England has such an enormous consuming public close at hand. People who are doing business in England, and especially in London, with no severe competition, would be driven out of business in very many cities that I could mention if I had time. But things here, as I said, are very easy, and where things are easy the natural result is to make the individual try less hard, and if he tries less hard he will seek the line of least resistance. On the other hand, if we could get the public to insist on something better, to insist upon the good thing and the beautiful thing rather than the just "will it wear?" we should be a great deal better off. It is really a fact—I speak with a certain amount of knowledge on this subject—that the usual customer

inquires of the assistant as to the durability of an article, no matter in what line that article may be. I even fancy that sometimes they ask if a bouquet of flowers will wear. Durability seems to be the chief thing instead of beauty. Most things are really made to throw away after they have lost most of their beauty; but in this country, where durability is such a fetish, people are made to feel that they must wear them until they are worn out, and the duty of those who lead in this project must be to educate the consuming public in that direction. How is that going to be done? I should like, if I could, to see everything in every detail done better in England, and better in London than anywhere else, to see perfection as nearly reached as possible in this great collection of people called "England" or "London." I would love to see the word "satisfaction" eliminated from the dictionary, and everything eliminated that is "quite good enough" if it can be done better. I should like to see the public demand that sort of thing, and then we should see the manufacturers looking round for bright young people of ability, skill and art to make their products better.

How will you educate the public to feel that way? For many years my home was in Chicago—a very active, hard-working sort of city. At one time we had an Exposition, as we call it, there. I differ from Sir Frank Warner in only one point in his excellent remarks, and that is when he said that Exhibitions must be Government-controlled. Personally, I object to the Government controlling anything which can possibly be avoided. A Government which does the work of governing has its hands full. At all events this great Chicago Exhibition, which was really a most beautiful affair, and cost a very large sum of money, was gathered together entirely under the auspices and under the control and direction of the men of business in that part of the world. We built the best buildings that we could; we employed the best architects that we could muster; we filled the buildings with the products of the whole world, gathered together on something like 700 acres of space. It was made a thing of beauty; it was a perfect production of the architects', the manufacturers', the artists' and the industrial managers' skill, and it was really a wonderful education. Chicago is a workshop. It is a great city containing 2½ million people, most of whom have sailed from Europe in the steerage and have come out there to make their daily living, and all those people have had to be brought up to the standard of knowing what life is on really rational lines. Chicago is all the time trying to educate this great crowd of people which has come within her walls to make a living, and nothing has done so much to make those people desire and hunger for the beautiful, to require the better, to be less satisfied with the commonplace, than that great Exhibition which was held for six months in 1893. If we could have in this country, managed, paid for, controlled, directed and advertised by the commercial classes all over this green earth a wonderful exhibition to which everyone, from the least important home in this great community to the very best, could go and learn and enjoy, and then go again and learn more and enjoy further, I think you would find a step of great importance had been taken in teaching the community that the beautiful is better than the commonplace, and that the delightful is better than the cheap.

The Germans learnt one thing in 1876 when they went to the World's Fair at Philadelphia. They sent over there a Government official to make a report to the Government as to the German exhibits that were there, and he made his report in three words—"poor and cheap." The fact that he told the German manufacturers that their exhibits, over which they had taken a great deal of pains, were poor and cheap did more than any one single thing to inspire and force the manufacturers of Germany to get from the common, the ordinary and the cheap, to the better. At all events it had the effect of pulling those people to the best of their ability out of their mediocrity, and putting them into a position of doing things a little better than they had done them before. If we could just dream out a beautiful Exhibition, held where everyone could get at it, in a central location where it was convenient, where it was easy to stroll in, and where everybody could pay a shilling and go in and learn something, I think it would go a long way towards making your most admirably proposed Exhibition a permanent and much-appreciated feature of the people and the manufacturers of this community.

Mr. John Turner (Secretary, National Amalgamated Union of Shop Assistants, Warehousemen and Clerks): I have been asked to say a word from the point of view of the workers with reference to this scheme. I have been wondering what direct part the workers of this country are going to play in this scheme, because I have been almost unable to discover it. Certainly the workers do play a very considerable part in the industrial arts; but, so far as the scheme before this meeting is concerned, there seems to be no corner in it in which they would have any direct opportunity of putting their point of view. There are two things which workers in industrial arts are very largely interested in. Firstly, with reference to the work itself; unless the work is of good quality, the worker can never find happiness in his work. I hope Lord Leverhulme will forgive me when I say that I was wondering how much happiness and how much improvement in industrial art an engineer could get out of working two or three automatic lathes. I wondered how much improvement in industrial art would come from it if he could work a design. It appears to me that any artistic instinct that the man might have retained in him, if he was an engineer and interested in metal, would not be improved by working at an automatic lathe for even four hours a day. His chance would only come at the end of that allotted task,

when perhaps he might begin working by hand on some metal and produce something really artistic which was pleasing to himself and to his fellows. No wonder that a narrow view is taken with reference to the limitation of output on the part of so many Trade Unionists. It is not quite true to say that in America the difference in wages is due altogether to the difference in output. It is partly due to a standard of life which probably has little relation to the output of work. The worker in America sometimes produces no more than the worker produces here, but, owing to the standard of life, he earns considerably more than the worker gets on this side of the Atlantic. But not only will the worker find happiness in his work if the quality is good. The workers are a considerable number in this country, and the very happiness in life of the workers, as well as other people, is bound up in the quality of the goods which are produced. They cannot have happiness in their life without good quality, and therefore the workers in a very large sense will be interested in any scheme that will raise the standard of quality so far as the goods of this country are concerned.

One important point in connection with the scheme is, I understand, that travelling scholarships for designers, for salesmen, and for buyers will be inaugurated. I am very pleased indeed to hear that that is the case, because I have a great deal to do with a body of salesmen and saleswomen. As an organisation we have been affiliated with an international federation of employees on the Continent. The Employees' Association of France have a large number of travelling scholarships, and before the war I had the pleasure of meeting a number of those who came over here, and it was then a cause of sorrow to myself to know that, while people on the Continent could come to England with these travelling scholarships, there was very little reciprocity to send our salesmen and saleswomen abroad to learn from the people there. I am, therefore, particularly pleased to find that it is proposed to give scholarships for designers, salesmen, and buyers, so that in the near future we may be able to reciprocate in that direction. But I still wonder what position the workers will occupy in this scheme. Certainly, so far as they are concerned, the time has come when they should be brought into it directly as workers, and if that can be done I believe it will be for the benefit of all. I do not believe the workers of this country are either very stupid or limited in vision. I believe they will be of service to those who want to promote the scheme, and if a way can be found for them to help, I believe it would be to the advantage of the objects which we all have in view.

THE CHAIRMAN: I regret to say that it is now necessary for me to leave the chair, as I have a Bill to conduct through the House, and I must ask you to excuse me.

MR. A. A. CAMPBELL SWINTON, F.R.S. (Chairman of the Council of the Royal Society of Arts): Ladies and gentlemen, on behalf of the Council of the Royal Society of Arts I desire, before Mr. Fisher leaves the chair, to ask you to accord him a most hearty vote of thanks for his presence here to-day, in spite of his multifarious duties. It has been of the utmost benefit that we have had Mr. Fisher to preside over us.

The resolution of thanks was carried unanimously.

THE CHAIRMAN: Ladies and gentlemen, I am very much obliged to you for the kind way in which you have received the vote of thanks. I only wish that Mr. Gordon Selfridge could persuade the House of Commons that durability should not be the sole test of speaking, because I can assure him that we suffer very much from the prevalence of that doctrine in the Mother of Parliaments.

The chair was then vacated by MR. FISHER and taken for the remainder of the proceedings by MR. CAMPBELL SWINTON.

MISS MAY MORRIS: If arrangements are made for the establishment of a museum or a permanent exhibition, I do urge that a small room should be set apart for the works of William Morris. As the years go by, I begin to realise that three generations have arisen since those wonderful days of 1860 onwards, and that to all the young boys and girls who come on pilgrimage to my house, William Morris is just a great tradition very far away. I should like that tradition to be drawn closer to their lives, and if there was such a permanent record of William Morris's work in the museum or exhibition, that object would be accomplished.

MR. F. V. BURRIDGE (Principal of the London County Council Central School of Arts and Crafts): For better or worse we have no Chicago Exhibition for the elevation of public tastes, but I think we have something in this country which also meets Lord Leverhulme's point when he talked about the doubtful fish that was advertised by good labels. It is my particular mission this afternoon to remind you that none of what you wish to bring about can be accomplished without a due fostering of those institutions which are responsible in this country, at all events at bottom, for the contents of the packages, and those institutions are, I venture to suggest, the schools of arts and crafts. The schools of arts and crafts should be the concern of the Board of Trade as well as of the Board of Education, because they are responsible for educating, in one way or another, the producer, the distributor, and the consumer. We have had teaching in those schools of art men who by their labours are really at the bottom of the scheme that we are considering to-day. Of those men I should like to mention Henry Wilson,

who has thrown a large portion of his life into the development of the very sort of scheme that we are considering to-day. He was the life and soul of the Exhibition in Paris which preceded the war, and which preceded the memoranda that have to a very large extent given birth to this particular movement. This movement is cumulative. It cannot depend upon any one man. The whole of this business is the development of the idea which has always been fostered by the crafts of this country. The manufactures of this country are dependent upon the crafts of this country, and unless we keep the crafts alive by fostering them in every possible way, the manufacturers will lose the basal stimulus on which they depend. The schools of art come into it in this way, that they should be the hotbed for the newer generations of young craftsmen in the same way that they should produce the newer generations both of distributor and consumer. I have been recently particularly concerned with the improvement of the position of the distributor, and I think we ought to pay very great attention to that man. No matter what the manufacturer or the craftsman may produce, he has to reach his public, and if the public is not reachable then he cannot dispose of the great things that he may produce. How is the public reachable? Through the distributor. And the consumer is dependent also upon the distributor, and until we get to the happy time when we can get such a development of public taste as Mr. Gordon Selfridge suggested, we must pay very great attention to the education of the person who stands between the purchaser and the person who consumes. Proper attention has not been paid to that by our authorities and schools; and if our schools will concentrate their efforts on the questions of importance in their particular districts, whether production or distribution, and do not dissipate their energies over an enormous curriculum that cannot be adequately covered, then I think the schools of art which have been erected can do the work that they are supposed to do. The health of this scheme will depend upon the health of the schools of art, on whom is dependent the education of the triumvirate —producer, distributor, and consumer.

Mr. W. Robert Colton, A.R.A.: It seems at the first blush that industrial art is very much divorced from what are commonly called the fine arts, but this I have always thought a great fallacy. Such is the fine gradation between the very greatest products of painting and sculpture, and those products worked into ordinary industrial materials, in moulding and in colour design, that there is no demarcation between the fine arts and the industrial arts. That is one factor which we must recognise if we are to succeed as producers of fine industrial arts. The idea that these arts are different in species and in kind is the one stumbling-block upon which the Board of Education has fallen. Our Government has spent large sums of money on art education, but the period between the time when the designer is trained and the time when he is a practical designer for any species of industrial art manufacture has never been bridged by our Government. It has never succeeded in applying its art-trained product to the real industrial design. That has always seemed to me to be the hiatus between the training and the application. As far as the Royal Academy is concerned, this movement has its every sympathy. It has perhaps in the past been driven along the line of least resistance to have exhibitions of a special sort and species; it is subject to public patronage like any other business or institution; but I think it has shown that it appreciates the future developments in the reconstruction of the trade of this country, and that it is of the highest importance that the industrial future of this country should be very much concerned with the finer development of art of an industrial character. I may remind you that it held a most successful Exhibition recently of industrial art and arts and crafts, and I believe it has every desire to help this great movement in every way in its power. Should this meeting form a scheme which will in any way require its help, the Royal Academy will, I am quite sure, be very glad to appoint a permanent representative from its council upon it.

The Chairman: The hour is getting late, and I propose, therefore, without further remark, to put to you the following resolution which was originally to have been moved by Mr. Fisher had he been able to remain:—"That this meeting cordially commends the scheme of the Royal Society of Arts for the Promotion of Industrial Art, and the Government scheme to establish a British Institute of Industrial Art, and approves the issue of a joint appeal for funds to realise these objects."

The resolution was then put and carried with one dissentient, and the meeting then terminated.

APPENDIX I.

Royal Society of Arts Scheme for the Promotion of Industrial Art.

I. *Objects.*

1. To encourage and co-ordinate movements towards the development and improvement of Industrial Art, with a view to maintaining for the trade of the British Empire its position in the markets of the world; and especially to stimulate closer mutual understanding and confidence between producers, distributors, educational authorities, societies with similar aims, and individuals interested in these aims.

2. To co-operate with Government Departments and other bodies in promoting exhibitions, and in particular with the Government

Scheme for a British Institute of Industrial Art.

[The Exhibitions contemplated would consist of exhibits selected for their artistic and workmanlike qualities, with the intention of stimulating production, commerce, and public taste.]

3. To initiate and encourage research, experimental and other work germane to the objects above indicated; to award grants for conducting such work; and to co-operate, whenever possible, with Government and other institutions founded for such purposes.

[It is considered highly desirable that researches should be made into a large number of materials in order to ascertain exactly their qualities and the uses for which they are most suitable. The qualities of many kinds of timber, *e.g.*, have not yet been scientifically studied.

The Authorities of the Imperial College of Science and Technology and of the National Physical Laboratory have intimated their willingness to co-operate with the Executive Committee of the Scheme for the Promotion of Industrial Art in matters connected with research. With their great staffs of scientific men of the highest distinction, and their admirably equipped laboratories, these institutions offer facilities for work of this kind which are probably unsurpassed.

Another object in view is the award of travelling scholarships to designers, buyers, salesmen, and others, in order to provide them with opportunities of widening their experience and cultivating their taste.]

4. To encourage propaganda work, especially by means of the facilities for lectures and papers afforded by the Royal Society of Arts within the scope of its Royal Charter, "for the encouragement of Arts, Manufactures, and Commerce," and those afforded by other bodies.

5. To raise a central fund to carry out these and such similar objects as may afterwards be determined by an executive committee to be set up at the public meeting to be held in October. The Royal Society of Arts shall be constituted trustee of the central fund.

[Sums given for special purposes by firms, individuals, and societies may bear perpetual designations to associate them with the donors' names, as is the case with other donations and endowments of which the Royal Society of Arts is trustee.

It is suggested that a sub-committee should be set up for each industry which should meet regularly and make recommendations from time to time as to the steps which it is desirable to take in order to promote the interests of that industry. The report of each sub-committee would be submitted to the executive committee, and considered by it both in regard to its general recommendations and to its financial requirements.]

II. *Administration.*

6. The scheme shall be administered by the above-mentioned executive committee, which shall consist of: (1) Persons representing contributors to the central fund; (2) members of the Industrial Art Committee of the Royal Society of Arts, and (3) others engaged in work covered by the scheme.

7. Pending the constitution of this executive committee, the Industrial Art Committee shall act for it.

APPENDIX II.

British Institute of Industrial Art.

The Board of Trade, in conjunction with the Board of Education, and with the advice of representative members of the Royal Society of Arts, the Arts and Crafts Exhibition Society, the Art Workers' Guild, the Design and Industries' Association, and various persons and organisations connected with manufacture and commerce, have framed a scheme for the establishment of a British Institute of Industrial Art, with the object of raising and maintaining the standard of design and workmanship of works and industrial art produced by British designers, craftsmen, and manufacturers, and of stimulating the demand for such works as reach a high standard of excellence.

Organisation of the Institute.

The Institute will be incorporated under the joint auspices of the Board of Trade as the Department dealing with industry, and the Board of Education as the authority controlling the Victoria and Albert Museum, and the methods by which it is proposed to achieve its object include:—

(*a*) A permanent Exhibition in London of modern British works selected as reaching a high standard of artistic craftsmanship and manufacture.

(*b*) A selling agency attached to this Exhibition.

(*c*) A purchase fund for securing for the State selected works of outstanding merit exhibited at the Institute.

(*d*) The establishment of machinery for bringing designers and art workers into closer touch with manufacturers, distributors, and others.

(*e*) The organisation of provincial and travelling exhibitions of a similar character,

either directly or in co-operation with other organisations.

In addition to the governing body, which will be responsible for the general management of the Institute, it is proposed to constitute an independent selection committee, consisting of persons of outstanding reputation and position in relation to design, craftsmanship, and manufacture, and no works will be eligible for exhibition which have not been submitted to and approved by this committee.

It is intended that articles of craftsmanship not intended for multiplication and trade products mechanically produced shall both be eligible for exhibition provided that they comply with the conditions, including those relating to British design and workmanship, and reach the required standard. Probably there will be two sections of the Exhibition for articles of craftsmanship and trade products respectively.

Financial Basis.

It is not at present intended that the Exhibition of the Institute shall be actually opened until after the war, but all preparatory steps are being taken so as to avoid delay when peace has been restored. It is hoped that the Exhibition will be permanently open to the public, except possibly on special days, on which admission may be confined to duly-accredited trade representatives on the lines of the British Industries Fairs. Arrangements will be made for the continual replacement of exhibits that are purchased or withdrawn. A suitable commission will be charged on sales effected through the Institute. There is reason to hope that within a short period of years the Institute may become self-supporting (except, of course, as regards the cost of purchasing for the nation selected works of outstanding merit). But it is necessary to provide for an adequate guarantee fund to ensure the stability of the scheme, at least during its initial stages, and thus to enable a high standard to be rigorously maintained without regard to immediate financial necessities. The Board of Trade confidently hope that such a guarantee fund will be forthcoming.

The above scheme has been framed, and will be worked, in close co-operation with the Council of the Royal Society of Arts, whose own scheme for the encouragement and co-ordination of movements towards the development and improvement of Industrial Art includes as one of its objects the support of the proposed Institute.

MARBLE AND GRANITE INDUSTRY IN VENICE DISTRICT.

Italy is one of the world's most famous sources of supply for both art and building marbles, and marble, granite, and building stones are the common materials used for buildings in that country. Venice is a fireproof city, built of stone of Istria and marble; and the foundations and first courses, at least, of all palaces, public and municipal buildings, Government and business edifices are of these materials.

Venice is immediately adjacent to famous marble quarries with an inexhaustible supply of raw material, worked by cheap labour. The Istrian stone, which is quarried just across the Adriatic, reaches Venice by the cheapest forms of water transportation, being loaded on sailing barges at the quarries, and disembarked at the exact point where it is to be used.

The most important quarries in the Veneto are at and near Verona, the Veronese red and yellow marbles having been favourite building stones since the time when the Colosseum at Verona was constructed. For building, they rank next to the stone of Istria in popularity, and are true marbles, while the stone of Istria is not a true marble, although a very hard limestone, that is much used in Venice because it resists the action of salt water and sea winds.

Besides their value for construction, the Veronese marbles are in great demand for decorative work. Among the names of the several varieties of Veronese marbles are white nembro, coral pink, white peach, partridge eye, yellow snail, yellow azure, and paradise.

A few years before the war a number of famous structures were built or decorated with Veronese marbles. In Vienna the Bourse, the municipal buildings, and the Parliament buildings were adorned with the red, white, and yellow marbles of St. Ambrogio and with stone of Incaffi. The post office at Verona used the red nembro of St. Ambrogio, and the façade of the post office at Zurich is adorned with the red and yellow marbles of St. Ambrogio. Vienna in recent years has made extensive use of Veronese marbles for decorative furniture.

The marbles, writes the United States Consul at Venice, are of excellent quality, and are variegated in hue from the light yellow of alabaster to dark yellow, from ashy to grey, from pale skin-coloured pink to blood red and vermilion, and are also speckled, shaded, spotted, girdled, streaked, veined, piebald, and mottled. They combine lightness with solidity, and are well adapted to the uses of sculpture.

There is a union of marble producers and exporters whose main object is the fixing of prices. This union, formed in 1908, is the Società Anonima Marmifera Veronese (Stock Company of Veronese Marble Producers). There is a similar but larger association, with headquarters at Carrara. In the Verona district there were 201 active quarries in

1913, the same number in 1912, and 207 in 1911. The value of the marble quarried in the rough state was about £32,000 per annum.

The second marble quarrying district in the Veneto is that of Vicenza, which produces the various sorts of "Pietre di Chiampo" and of "Pietre di Valdisole." Large quantities of building stones and marbles were shipped to the United States a few years ago by a Vicenza company. The Genoese marbles are very beautiful but are used only for decorative work, as they crumble easily. The Carrara marbles of the finer quality for use of the sculptors vary greatly in price, according to the dimensions of the block required, as a flaw would often spoil an entire block. Fine quality white Carrara often costs £32 to £40 and more per cubic metre.

GENERAL NOTES.

THE GOTHENBURG FAIR.—The Swedish Fair held at Gothenburg in July bears witness to the rapid development of the commercial energy of Sweden during the war. From having once been the humble vassal of the great foreign markets, Sweden has now progressed so far that she may venture to create an institution comparable to the goods-markets now held in other countries. Dr. Köhler, managing director of the Leipzig Fairs, contributes to *Der Welthandel* (August 2nd) an article, in which he asserts that the sample fair held in Gothenburg between July 8th and 14th may be regarded as highly successful. The fair was visited by some 30,000 persons, and sales to the value of Kr.40 mill. took place.

BOARD OF TRADE ADVISORY COUNCIL.—In the *Journal* of October 18th the names of five Fellows of the Royal Society of Arts who are Members of the Board of Trade Advisory Council were published. The name of a sixth—Sir Gerard A. Muntz, Bart.—was inadvertently omitted.

POTASH AS A BY-PRODUCT.—Replying to a question in the House of Commons on October 24th, Mr. Kellaway (Ministry of Munitions) said that a scheme for recovering potash on a commercial scale from the blast furnaces used in the manufacture of pig-iron was approved last year. In consequence the Ministry had encouraged the installation at various ironworks of gas-cleaning plant designed to extract from the furnace gases potash-bearing dust. Certain of these plants were now in operation, others were under erection, while others, again, were in course of construction. A factory had also been erected at which muriate of potash, free from deleterious impurities, was being manufactured from such dust. This factory was capable of dealing with all the dust that could be collected by the gas-cleaning plants now under erection and construction. As other gas-cleaning plants were installed, it was proposed to erect other factories in suitable localities. A small amount of potash was also being obtained as a by-product of the cement industry, and experiments were at the present time being carried on with a view largely to increase the amount so recovered.

THE EMPIRE'S MINERAL RESOURCES.—The Imperial Institute, in continuation of its publications with reference to the mineral resources of the Empire, has now issued a map with diagrams indicating the sources within the Empire of the chief metals of commercial importance. The outline map shows the occurrence in each British country of important metallic ores, and also the existence of deposits at present unworked. The diagrams attached to the map give for 1915 the production of each country, as well as the total British output and the world's output of each important metal or ore. Among the striking features disclosed are that in the case of gold more than half the total production is within the Empire, the principal producer being South Africa; with silver, the British proportion is rather less than one-fifth, the principal producer being Canada; in the cases of manganese, chromium, tin, and molybdenum, the British proportion is near one-half. It is remarkable that there appears to be scarcely any production of the valuable metals mercury and platinum within the Empire, so that we are almost entirely dependent on foreign countries for supplies.

AMERICAN GUN PLANT IN FRANCE.—The relining of big guns is one of the biggest salvage operations in the war, says the *Iron Trade Review*. The intense heat to which the inner surface of the gun is subjected soon destroys the rifling grooves, and the gun is rendered practically useless, though all other parts are as good as new. When a gun is brought into the shop to be relined, the old lining is first bored out. The jacket is then heated, and the new lining inserted. The gun is next dipped into a shrinkage pit, which shrinks the jacket tightly round the new lining. A large plant for relining the heavy guns in use by the American Expeditionary Force is to be erected in France at a cost of from twenty-five to thirty million dollars. In magnitude it will, it is said, be comparable to the Krupp works in Essen. The plant will include gun-boring lathes, engine-lathes, grinders and rifling machines, extensive shrinking pits, giant travelling cranes, and electric generating plant, a huge boiler-house, and sufficient housing facilities for the whole project. For gun-boring lathe designs for 102 inches swing, there is in construction a giant planer, the base of which is so long that a correction had to be made in the design for the earth's curvature. This base is 500 feet in length.

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REGISTERED AS A NEWSPAPER.

Royal Society for the Encouragement of Arts, Manufactures and Commerce.

The Royal Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for the Encouragement of the Arts, Manufactures, and Commerce of the country.

At present the Society numbers about three thousand Fellows. The annual subscription is Two Guineas, the life subscription Twenty Guineas. There is no entrance fee.

Fellows are entitled to be present at all the meetings of the Society. These include the Ordinary Meetings, held every Wednesday during the Session, when papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed; the Meetings of the Indian and Colonial Sections, at which subjects connected with our Indian Empire and the Colonies and dependencies are considered; and the various lectures on technical subjects delivered under the Cantor and other trusts. Fellows also receive a weekly copy of the *Journal*, which contains full reports of the Society's proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce; and they are entitled to the use of the library and reading-room, and to attend the Conversazioni.

Proposal forms, and further particulars relating to the work of the Society, may be obtained from the Secretary, Mr. G. K. Menzies, at the Society's House, John Street, Adelphi, London, W.C. (2)

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

ARRANGEMENTS FOR THE SESSION.

The Opening Meeting of the One Hundred and Sixty-Fifth Session will be held at 4.30 p.m. on Wednesday, November 20th, when an address will be delivered by ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council. The subject of the address will be "Science and the Future."

The following arrangements have been made for the meetings before Christmas :—

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m. :—

NOVEMBER 27.—LORD D'ABERNON, G.C.M.G., Chairman, Central Control Board (Liquor Traffic), "Liquor Control in Various Countries."

DECEMBER 4.—BENJAMIN SEEBOHM ROWNTREE, "Housing after the War." LORD HENRY CAVENDISH BENTINCK, M.P., will preside.

DECEMBER 11.—MAJOR-GEN. SIR FREDERICK SMITH, K.C.M.G., C.B., F.R.C.V.S., "The Work of the British Army Veterinary Corps at the Fronts." The DUKE OF PORTLAND, K.G., G.C.V.O., will preside.

COLONIAL SECTION.

Thursday afternoon, at 4.30 p.m. :—

NOVEMBER 21.—SIR EVERARD IM THURN, K.C.M.G., C.B., LL.D., "The Present State of the Pacific Islands." SIR CHARLES LUCAS, K.C.B., K.C.M.G., will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m. :—

NOVEMBER 28.—BHUPENDRANATH BASU, Member of the Council of India, "Some Aspects of Hindu Life." The Most Hon. the MARQUIS OF CREWE, K.G., will preside.

Papers to be read after Christmas :—

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S. (Subject to be announced later.)

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

FREDERICK WILLIAM KEEBLE, C.B.E., M.A., Sc.D., F.R.S. (Director of Horticulture, Food Production Department), "Food Production by Intensive Cultivation."

B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

A. F. KENDRICK, Department of Textiles, Victoria and Albert Museum, "English Carpets."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

LIEUT.-COLONEL H. G. LYONS, D.Sc., F.R.S., "Meteorology during and after the War."

W. L. HICHENS (Messrs. Cammel Laird & Co.), "The Wage Problem in Industry."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

J. J. CROWLEY, D.Sc., "The Use of Electricity in Agriculture in Germany."

SIR FRANK HEATH, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

WALTER LEONARD LORKIN, A.M.I.E.E., "Electric Welding and its Applications."

PROFESSOR JOHN CUNNINGHAM MCLENNAN, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

SANDFORD J. KILBY, "Indian Salt Manufacture."

H. KELWAY-BAMBER, M.V.O., "Coal and Mineral Traffic on the Indian Railways."

PROFESSOR H. E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Soil Exhaustion in India and its Influence on the Value of Crops."

LORD MONTAGU OF BEAULIEU, C.S.I., V.D. (Subject to be announced later.)

Indian Section.

Thursday afternoons, at 4.30 p.m. :—

January 16, February 13, March 13, April 3, May 15.

Colonial Section.

Tuesday afternoons, at 4.30 p.m. :—

February 4, March 4, May 6.

Cantor Lectures.

Monday afternoons, at 4.30 p.m. (unless otherwise announced) :—

James C. Philip, O.B.E., M.A., Ph.D., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology, "Physical Chemistry and its Bearing on the Chemical and Allied Industries." Three Lectures.

December 2, 9, 16. 5 p.m.

John A. Fleming, M.A., D.Sc., F.R.S., Professor of Electrical Engineering, University College, "Scientific Problems of Electric Wave Telegraphy." Three Lectures.

February 10, 17, 24.

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Fuel Economy." Three Lectures.

March 10, 17, 24.

Juvenile Lectures.

Wednesday afternoons, at 3 p.m. :—

Charles R. Darling, A.R.C.Sc.I., F.I.C., Lecturer in Physics City and Guilds Technical College, Finsbury, "Liquid Drops and Globules." Two Lectures.

January 1 and 8.

PROCEEDINGS OF THE SOCIETY.

COBB LECTURES.

RECENT DEVELOPMENTS IN LEATHER CHEMISTRY.

By Henry R. Procter, D.Sc., F.I.C.,
Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University; Director of the Procter International Research Laboratory.

Lecture II.—Delivered May 14th, 1918.

We are now in a position to consider the actual changes of the tanning process, which are partly chemical and partly dependent on the physical process known as "adsorption," which itself may often be merely a surface chemical reaction which cannot be completed in limited time.

So far we have discussed the processes necessary for the preparation of the hide or skin for tanning. It now remains to study its actual conversion into leather. Up to this point, though cleansed and free from extraneous appendages, the hide remains merely raw pelt, wet and easily putrescible, or, if dried, hard, horny, and translucent. Leather, on the other hand, is non-putrescible, opaque, and pliable, when dry, to a greater or less degree.

It is now sixty-five years since Knapp, in a remarkable thesis on "The Nature and Essence of Tanning," gave the first intelligible account of the nature of the change. As has been stated, the raw hide consists of a mass of fibres swollen with water, existing partly in the jelly of which the fibres consist, and partly retained by capillarity between them. If allowed to dry, the loosely-held capillary water evaporates, and the jelly-fibres come into contact while still moist and swollen, and adhere to a solid mass. If on the other hand the fibres can be made to give up the jelly-water while still separated, they no longer adhere, but remain as a fibrous felt with all the physical characteristics of leather. Knapp accomplished this by soaking the pelt in alcohol, in which the fibres are not soluble, and which gradually took the place of the capillary water, and then removed that of the jelly, so that on finally evaporating the alcohol no adhesion took place. Such a leather, if soaked in water, slowly returned to the raw-hide condition, but if a little stearic acid was dissolved in the alcohol it remained as a coating on the fibres and prevented or delayed their re-absorption of water. On these facts he based the theory that the essential of tanning was the coating of the fibres with some constituent of the tanning solution which would make them non-adherent, and he concluded that tanning was a mechanical rather than a chemical process.

Knapp's conclusions were only a part of the truth. He offered no explanation of the causes of dehydration, which, in my view, is an essential part of the operation; and he could not know of the production of permanent leathers by formaldehyde and by bromine, from which no coating substances can be deposited, but which alter the chemical nature of the fibre itself.

Let us first take the tawing or ordinary alum and salt tannage, and consider how far we can apply to it the principles we have already discussed. Aluminium sulphate (which is now generally substituted for alum) partially

hydrolyses on solution into sulphuric acid (hence its sour taste) and alumina which remains in solution (possibly colloidal), with an excess of the normal salt. If hide be placed in such a solution it absorbs the free sulphuric acid and swells, and as free acid is essential to prevent hydrolysis a further portion of acid is liberated and absorbed, and the hydrolysis proceeds much further than it would in absence of the hide, leaving an alumina solution in which the alumina base preponderates over the acid, and which is possibly to be viewed merely as a solution of alumina in the normal salt. Such solutions are known as basic. The swollen leather, if dried in this state, would prove stiff and undertanned, as swollen leather usually is. If, however, common salt be added to the mixture, pickling takes place, the swelling is reduced, and the fibres contracted, so that they dry without adhesion and a sort of leather is formed. These dehydrated and separated fibres now absorb or attract to their very extended surfaces the alumina from the basic solution in which it is very unstably dissolved, which increases the permanence of the non-adhesion. At first this deposition is probably purely mechanical, but if the leather is kept for some weeks under ordinary atmospheric conditions a further change takes place, possibly, as Wilson thinks, a chemical combination to a gelatine-alumina salt, from which the alumina can no longer be completely washed out. If in place of a normal aluminium sulphate solution one is used which has already been rendered basic by the careful addition of soda, the hide does not swell, and the use of salt can be dispensed with, and a somewhat more permanent and more completely-tanned leather results.

Alumed leather is never very resistant to wetting, and chrome leather, which has largely replaced it, is very different in this respect, and if properly tanned will stand even boiling in water without shrinkage, and will remain soft on drying. It was first made by Professor Knapp in 1852, but he, unfortunately, did not perceive its value, and it was left to be re-invented in America by Augustus Schultz in 1884, who produced it by a different method.

Chromium exists in its salts in several different degrees of oxidation, and those of tri-valent chrome are of precisely the same type as those of alumina, and hydrolyse and form basic solutions in a similar way. Chrome alums are the counterparts of alumina alums, in which chrome oxide (Cr_2O_3) is substituted for alumina (Al_2O_3) and in principle basic chrome tannage is identical with alumina tannage, though it yields a much more perfect sort of leather. Chrome alum with sufficient salt will produce a lightly-tanned but very pliable leather, but in practice basic solutions are always used, salts of the empirical formula, $Cr\left\{\begin{matrix}Cl_2\\OH\end{matrix}\right.$, or the corresponding sulphates being generally suitable, though for special reasons more or less basic solutions are often employed. Chrome salts are manufactured from chrome iron-ore, by furnacing with potash or soda, or with mixtures of these and lime, which yields a series of crystallisable yellow chromates, in which chromium trioxide acts as acid, precisely in the same way and with the same type of formula as sulphur trioxide in the sulphates and sulphuric acid. So also as SO_3 forms bisulphates with half the amount of base, CrO_3 forms bichromates, and these are the forms in which it occurs most abundantly in commerce. Bichromates readily give up three atoms of their oxygen, and hence are largely used as oxidising agents in dye-manufacture and similar industries, and the reduced chromate yields crystallised chrome-alum which is thus often something of a by-product.

Hence for tanning purposes it is convenient, according to the market, sometimes to start with chrome-alum, sometimes with bichromate, according to which is cheaper. In the case of chrome-alum all that is needed is to dissolve it in water, and then add gradually, and with constant stirring, a solution of ordinary washing soda, 25 to 30 per cent. of the chrome-alum used. Gradual mixture is essential, or the Cr_2O_3 precipitates, and will not redissolve. I published this process in 1898, and it has been largely used, but another formula I gave a year earlier, starting from bichromate, has also been very successful. In the latter the bichromate is dissolved in warm water, a quantity of sulphuric or hydrochloric acid, calculated to leave the desired basicity, is added, and then sugar or glucose. A violent oxidation sets in—some heat, and large quantities of CO_2 are produced, and the orange-yellow solution rapidly changes to a dark blue-green tanning liquor. Some aldehydes are also formed, which take part in the tanning, and yield a slightly softer leather than the chrome-alum liquor. A curious circumstance noted in this connection is that under some conditions a liquor results which is purplish instead of blue-green, and will not tan properly. A further investigation has revealed that this was due to the formation of

saccharic or some other dihydroxy acid, and to the further discovery that the salts of dihydroxy acids, and especially Rochelle salt (sodium-potassium tartrate), have the power of completely redissolving the chrome from chrome leather, and again reducing it to the state of raw pelt, a fact not without its technical uses.

At the present time both chrome-alum and every form of glucose or sugar are scarce and costly, and it becomes desirable to devise some other mode of preparing chrome-tanning liquors. I find that if sulphurous acid gas, either pure or mixed with air, as from burning sulphur, is passed into a solution of bichromate till it smells of burning sulphur, a tanning liquor, or "chrome extract," is produced of suitable basicity for sole-leather, and which merely requires dilution. I publish this method now for the first time. A solution of sodium bichromate of 4 lb. per gallon of water gives an "extract" of about 18½ per cent. of Cr_2O_3. The equation is—

$$Na_2Cr_2O_7 + 3\ SO_2 + OH_2 = Na_2SO_4 + 2\ Cr(OH)SO_4$$

if the reaction is complete.

The tannage with such liquors can be done either by suspension in pits of liquors of gradually-increasing strength in about three or four days, or in rotating drums like churns, in a much shorter time and without difficulty.

I mentioned earlier that Schultz, in 1884, invented a different chrome-tanning process, and its principles will now be easily understood.* It is generally known as the "two-bath" process in distinction from the single-bath method just described. The prepared skins are first treated in an acidified bath of bichromate (practically one of dilute chromic or dichromic acid). This has no tanning effect, but the skins take up the free acid, and are coloured bright yellow throughout. Only the free acid is absorbed, and a good deal of bichromate is often left in the bath, and sometimes thrown away.

The skins are now transferred to a reducing bath, generally of acidified sodium thiosulphate ("hypo"), containing free thiosulphuric acid and sulphurous acid, and it is here that the actual tannage takes place, the dichromic acid being reduced in and among the fibres to a tanning basic salt. The reducing process is chemically a very complex one, varying with the amount of acid used, and the rapidity of its addition, and even affected, as Stiasny has shown, by the trace of arsenic sometimes present in sulphuric acid; but free sulphur is regularly one of the products, and this, deposited between the fibres, tends to produce fulness and softness of the leather, which is usually also of a lighter colour. In spite of its more complicated character, the two-bath method is quite as rapid as the one-bath, since the materials employed are all crystalloids, and diffuse into the skin more rapidly than the partially colloid one-bath liquors.

The hides or skins, having been converted into leather by either of the processes described, still contain free acid and chrome-salts not sufficiently basic to be permanently fixed. This is remedied by "neutralisation," which consists in treating the skins with a weakly alkaline solution, so as to bring all the chrome present into a sufficiently basic state. If, however, *all* acid is removed from the chrome-salt, so as to leave Cr_2O_3 only, it appears to lose its tanning effect, and the skin becomes hard and pelty, so that considerable caution, and the use of alkaline solutions sufficiently weak completely to penetrate the skin without overhardening the surface, are essential. Weak solutions of borax are frequently employed, but even these have a hardening effect if used too freely, and a solution, proposed by Stiasny, of about 2 per cent. of ammonium chloride or sulphate and 2 to 4 per cent. of washing soda, is much better, as it can be so adjusted as to give the requisite neutralisation without danger. The soda, of course, decomposes its equivalent of the ammonium salt, giving free ammonia, and the alkalinity of this already weak base is further reduced to any required extent by the presence of the neutral ammonium salt, which by a well-known law diminishes its ionisation.

It is not essential that the interior of the skin should be fully neutral, as this is secured by a succeeding process, that of "fat-liquoring." The fat-liquor is a solution of a nearly neutral soap, in which a small quantity of oil is emulsified, and in which the skins are drummed. The oil and soap penetrate, coat, and lubricate the fibres, giving softness and additional water-resistance, and convert any remaining traces of unfixed chrome into insoluble chrome soaps. If the surface is insufficiently neutralised, such soaps are formed outside the skin, and adhere to it as a sticky

* In his original process Schultz added only about two-thirds of the hydrochloric acid necessary for the complete liberation of the chromic acid of the bichromates, and, for some reason incompletely understood, the best results are not obtained when the exact theoretical quantity is used. Eitner has, however, got good results by using acid somewhat in excess of the theoretical amount (equal parts of bichromate and 33 ozs. hydrochloric acid), and such a bath can be exhausted by a second lot of skins. Skins are also frequently pickled before chroming.

mass, which renders the subsequent dyeing and finishing impossible.

Chrome sole-leathers are not usually fat-liquored, and sometimes not even neutralised, but are dried out and impregnated with a melted mixture of waxes and rosin, which gives firmness and water-resistance.

Several other mineral tannages are possible, and especially those with iron, which forms salts analogous to those of aluminium and chromium, but which have not yet attained any commercial importance.

We may now pass on to notice very briefly what is the oldest and, perhaps, still the most important of tanning methods—the vegetable tanning process. In principle this is practically the same as was used by our forefathers, though in detail it has undergone great modifications, the most important of which is the use of much more concentrated solutions produced either from exotic materials naturally stronger than proverbial oak-bark, or concentrated artificially by the use of the vacuum pan. A good instance of the latter is the very important "oak-wood extract." Oak-wood naturally is only about a quarter as strong as oak-bark, and can hardly be used for direct tanning, though large quantities of branch-wood, sawdust, and other waste are available. By the concentration of weak liquors, syrupy liquids containing 25 to 30 per cent. of tanning matters are produced, which are suitable for modern requirements. The sources of such extracts were principally Southern Austria and Northern Italy, and their disappearance during the war, together with that of the Turkish acorn-cups, known as "valonia," has led to an absolute famine of tanning materials, and contributed much to the scarcity and enhanced prices of leather.

In principle the process consists in soaking the prepared hides in solutions of the class of organic substances, known as "tannins," which differ considerably in chemical constitution, but have the common characteristics of precipitating gelatine and converting skin into leather, and are very widely distributed in barks, woods, leaves, and even roots. Whether the precipitation of gelatine and the analogous action on skin are strictly chemical or physical processes has been much discussed, but the facts are as follows. Both tannins and gelatine are distinctly colloid in character—that is, they have either very large molecules, or these molecules exist in groups in the liquid, as colloid and not true molecular solutions. These particles are electrically negatively charged, while gelatine and skin fibres in slightly acid solution are positive. When, therefore, the two are brought together they attract each other by their opposite charges, unite, neutralise, and precipitate. The mechanism of the combination is not different from that of positively and negatively charged ions, such as sodium and chlorine, but it deals with whole molecules or particles instead of ions, and it seems a matter of taste whether we call it chemical or physical. In faintly alkaline solution the skin or gelatine particles, from their amphoteric nature, take negative instead of positive charges, and in this condition are not tanned or precipitated by tannins. Hence in tanning, faint acidity of the liquors is essential, though what is the *optimum* acidity has not been fully determined, and must depend upon the character of the leather desired. Acidity causes swelling of the fibres which leads to hardness and stiffness, and thus for the softest and most flexible leathers the smallest possible swelling is required, while for sole much more is desirable. The degree of swelling is also affected by the neutral salts, as was earlier explained, so that the solution of the problem does not merely depend on acid-concentration. The minimum swelling is obtained slightly on the alkaline side of absolute neutrality, on which tannage would not be practicable.

While what may be called the first stage of tanning is purely chemical in the sense which has been explained, there comes, at least with the heavier leathers, a stage in which adsorption or surface-attraction predominates, and when a sort of chemical equilibrium has been attained, the fixation of the less soluble and more colloid constituents of the liquors on the surface and between the fibres still goes on and adds to the weight and solidity of the leather, and no doubt in the old and slow methods of tanning earlier in vogue this played a larger part than it now does. The matters so deposited are principally ellagic acid (bloom) and the anhydrides or oxidation-products of tannins, which are only slightly soluble in water, and easily separated from it.

Besides the quickening due to the use of more concentrated liquors, many attempts have been made to quicken the slow diffusion into the leather of the colloid and slowly diffusible tannins. The most successful of these has been by the mechanical movement and bending of the hides in rotating drums and other similar devices, which cause a sort of pumping action between the fibres, and heavy leathers can be

tanned apparently well in three or four days which would take as many months by the old diffusion process. It is difficult to say to what extent such processes are in use, as drum-tanned leathers have not a very good reputation, and tanners are not anxious to advertise the fact that they make them, but there is no doubt that large quantities of leather are wholly or partially so made, and within limits this is very justifiable, especially under war conditions.

Much has been talked from time to time of the use of electricity for quickening tanning. Colloid particles are moved by electric currents by the effect called "electrophoresis," and may so be forced into or through leather, and it is pretty certain that tanning can be hastened in this way, though whether to an extent and at a cost commercially profitable may still be an open question.

The "vacuum" process is an interesting method of quickening tanning, and is being used on a considerable scale by the limited company which owns the patent. The hides are suspended in vats, which can be exhausted to so high a vacuum that the liquors actually boil in and round the hides at a temperature not exceeding 75 to 80° Fahr., and the interchange of liquor so caused considerably increases the rapidity of tanning. The process has little in common with the vacuum processes used in forcing preservatives into wood, which in the dry state is filled with air; this expands and escapes under reduced pressure, while hides contain only water, which does not practically expand unless it boils, and hence low vacua are useless.

There are many processes in important commercial use which are combinations of mineral with vegetable tannages, and especially with chrome and alumina, which contain nothing new in general principle, and of which time does not allow description, though the fact is interesting that hide saturated with the one is still capable of absorbing the other, probably because of its amphoteric nature. One of the latest of these is "pyrotan," a combined alumina and vegetable tannage, in which the alumina is precipitated and fixed in insoluble form by sodium pyrophosphate.

A more interesting study is the action of aldehydes, and especially of formaldehyde, in leather-making. Formaldehyde is a volatile liquid which evaporates without residue, so that it cannot well deposit anything on the fibre, according to Knapp's theory. It forms polymerised or conjugated compounds with many substances, and among others with hide-fibre, which it renders insoluble in boiling water. Applied to hide in the swollen condition, it fixes it in that state, and therefore has been applied as a preparation for hides for rapid vegetable sole-leather tannage. Payne and Pullman patented a method (1898) for its use as a tanning agent in conjunction with sodium, carbonate, and other alkalies, and very successfully made both imitation buff-leathers for military accoutrements, and soft washable leathers for gloves. Professor Meunier (1912), however, has shown that it is not the alkalinity, but the dehydrating effect of the sodium carbonate, which is important, and that other dehydrating salts, such as sodium thiosulphate, can be used with equal effect. A strong solution of potassium carbonate alone will produce a perfectly supple white leather, which, of course, becomes pelty again by washing, and dries hard and horny. If, however, three parts of neutral formol be added to the alkaline solution, a similar white leather is produced, which perfectly resists washing. The effect of formol is therefore merely to fix the skin-fibre in the condition, swollen or dehydrated, in which it finds it. Formaldehyde can be used in this way in connection with vegetable, chrome, or alumina tannages.

Interesting tannages which may be related to aldehyde tannages are those produced by the action of oils, as in washleather, buff, and buckskin, and the best modes of fur-dressing. Common washleather ("chamois," or "shammy" leather) is a typical example, and is produced by fulling the flesh sides of sheepskins in "stocks" while adding fish- or whale-oil until the pelts are thoroughly saturated. They are then packed in boxes, where they heat rapidly by oxidation, so that they must be taken out and aired at intervals, not merely to provide fresh air, but to prevent dangerous overheating. The skins turn deep yellow, and are converted into leather by the oxidising oil, and large quantities of pungent acrolein, or acryl-aldehyde (very lachrymatory), from the dehydration of the glycerine are given off. When heating ceases, the skins are wrung or pressed to remove surplus oil, which is valuable for stuffing other sorts of leather (degras, moêllon, sod-oil), and after washing with soda or potash solution, and fluffing on an emery wheel, are ready for use. Knapp's simple explanation that the process is an isolating and coating of the fibres with oxidised oil products is negatived by the fact that all the

latter are saponified, and washed out by alkaline solutions, and also the plausible view that the acryl-aldehyde is the real leathering agent, since Wood has shown that equally good leathers can be made with the fatty acids of oils from which the glycerine has been removed. This does not, however, entirely negative the aldehyde explanation, since only "drying" or unsaturated oils can be used, and their acids frequently split at an unsaturated bond, giving aldehydes as products. Marine oils are invariably used in practice, but Fahrion has shown that linseed and other unsaturated vegetable oils will also produce the effect, and the very tough and beautifully white Japanese leather, used for brace tabs and the like, is made with rape oil. Fahrion shows that oils must have at least two double linkages to produce this effect (marine oils have three or four), and Meunier points out that this produces a quinonoid structure by oxidation.

Marine oils are largely used in currying vegetable tanned leathers, and if the latter are not fully tanned, produce a sort of supplementary oil tannage very advantageous to the quality.

In addition to the present methods of making leathers there are many others possible, and some which have been commercially used on a limited scale. Meunier has shown that leather may be produced by the action of bromine, probably by forming insoluble bromamines, and that the various quinones are quite practical tanning agents, being partially converted into hydroquinones and giving good brownish-coloured leathers. He attributes the action of vegetable tans to the quinonoid bodies already present or formed by oxidation, and has shown that the power of most phenols to insolubilise gelatine is dependent on quinones formed by oxidation. A good many "synthetic tannins" have been patented, bearing no close chemical relations to the natural tannins, but having pronounced tanning properties. Much the most important of these are Stiasny's "Syntans," one of them, "Neradol" being now largely manufactured in this country by Government license under various names, and used in conjunction with other materials for plumping and bleaching, as alone it gives an almost white, but somewhat empty leather. It is produced by condensing sulphonated cresols with formaldehyde. Zacharias long ago showed that many aniline dyes, and especially the methyl violets, will also produce leather if used in sufficient quantities.

Distinguished from these are various colloid precipitates which, drummed into the skin, convert it into leather by coating and separating the fibres according to the old Knapp theory. In the two-bath chrome process the sulphur precipitated on the fibre considerably increases its softness and fulness, and by treatment with acids and sulphur-yielding compounds without the chrome, purely sulphur leathers may be made. Freshly precipitated alumina has considerable tanning properties, and phosphate leathers may be made by precipitating phosphate of lime in the skin, while most metals giving basic and colloid salts, as for instance titanium, may be used in producing leather. A process for tanning with colloidal silicic acid has been patented by Mr. A. T. Hough (English Patent No. 17,137 of 1915), which seems to give results of considerable practical value.

Probably enough has been said to show that no single theory can account for all the various ways in which leather can be made, and that there is no limit to the varieties which may be produced.

INDUSTRIES AFTER THE WAR.

IV.—TEXTILES (*continued from p. 755*).

Silk.

The manufacture of silk goods on a commercial scale in these isles appears to have begun with the immigration of Flemish and Huguenot weavers in the sixteenth and seventeenth centuries. From the first the trade was a protected one. Without protection it would probably never have taken root on this side of the Channel at all, as it had to face the competition of countries where silk industries had been in existence for hundreds of years and had attained a high degree of efficiency. Comparative prosperity prevailed until the adoption of Free Trade and the ratification of the Cobden Treaty. As compared with the United States—now the largest purchaser of raw silk in the world—France, Germany, Italy and Switzerland, the English industry is not in the front rank of our industrial activities. Statistics prepared by Sir Frank Warner, K.B.E., and quoted in the report of the Board of Trade Committee, show that in 1911 the entire production of silk amounted to 24,613,000 kilos, our share being under 630,000 kilos. America has gone ahead immensely in recent years, having increased her consumption from two million kilos in 1892 to twelve million kilos in 1913. In normal times approximately 66 per cent. of the raw material is supplied by Japan and China and 19 per cent. by Italy and France. A generation or so ago Japan only produced some seven thousand bales, and the quality was indifferent; her exports of "superlative silk" last year (to say nothing of her home consumption) were expected to total 150,000 bales,

valued at thirty million pounds sterling. Germany, though ranking second among the consuming countries in Europe, does not produce any raw silk whatever, and Austria-Hungary's production has been less than half her consumption. Turkey is the sole enemy country with a considerable surplus. Within the past fifty years there has been a serious decrease in the Indian supplies, largely in consequence of the deterioration of the Bengal cocoon and inferior reeling; nevertheless, the prospects in India are described in the report under notice as promising. Under qualified supervision the quality would be greatly improved. Kashmiri silk, grown at an altitude of 6,000 ft., compares favourably with the Japanese varieties. There is little doubt, the Committee says, that the foothills of the Himalayas lying within the United Provinces, the Punjab, Bhutan, Sikhim and Nepaul, are as well adapted to sericulture as those in Kashmir, where it is a State monopoly. The population of the districts referred to is almost equal to that of Japan and the area is much larger. "The main desideratum is a spirit of enterprise similar to that shown by the Government of Kashmir, and it would appear that efforts should be made by the Indian Government to encourage the development of sericulture within this large area." In the past two years operations on a limited but definite basis have taken place in the Native State of Patiala, "under the supervision of a native graduate of the Montpelier School in France." The first parcels of raw silk reaching this country from Patiala are described by experts as equal to the best Kashmir. With the exception of a small quantity from Kashmir, Indian waste is not used by English spinners because it is "mixed with impurities." In this section of its report the Committee makes the following recommendation: "Although the supply of raw silk and silk waste keeps pace with the continually increasing world's consumption, we recommend the development, under efficient direction, of sericulture in India and its stimulation and encouragement in those parts of the Empire where climatic and labour conditions are favourable." With the adoption of scientific methods, there are possibilities in the African colonies, especially Uganda and the highlands of Rhodesia.

Considerably more than thirty-six million pounds of "silk waste," from which schappe, spun yarns, sewings and noil yarns are made, is produced for consumption in Europe and America.

The British silk output in 1907—there are no later authentic figures—was of the value of £5,236,000, made up as follows: Piece goods, £2,262,000; spun silk yarns (including sewing silks), £1,250,000; lace, net trimmings, etc., £879,000; thrown silk, £394,000; and miscellaneous articles, £451,000. Fifty-three per cent. of the whole was disposed of in home markets. The Committee divides the trade into various groups, viz.:—

(a) *Spun Yarns and Sewing Silks.*—This is the most important single branch of the industry in this country. Of a total of 32,000 operatives employed in the whole industry about 10,000 are engaged in the spinning of yarns from waste silk. English spun yarns are said to be the best in the world, and are exported to Calais and Malta for lace-making, and in large quantities to the United States. The industry is well organised, fairly prosperous, and is mainly established in Yorkshire and the adjacent counties of Lancashire, Cheshire, and Staffordshire. The principal centres are Brighouse, Bradford, Leek, Congleton, Macclesfield, and Taunton. During the past few years spinners have been well employed. Competition in the past has been met with from Switzerland, France and Italy, but since the year 1912 there has been a considerable increase in the imports of Japanese spun yarns. British spinners regard this competition as a serious menace for the future.

(b) *Tie Silks, Cravats, Mufflers, Handkerchiefs.*—The manufacture of high-grade articles for men's wear has for long been one of the strongest branches of the silk industry. British fashions still lead the world in these articles, and although the industry has not increased to any appreciable extent, our manufacturers appear to be holding their own in the best classes of goods where design and quality are essential features and price is not of great importance. In the cheaper articles, however, Germany and Austria were very strong competitors before the war. Macclesfield is the centre of this industry, which is also carried on in the Glasgow district, Norwich, and the West Riding of Yorkshire.

(c) *Mourning Crêpe and Crêpe de Chine.*—Mourning *crêpe* is almost exclusively a British production, and is manufactured in the eastern counties of England. The principal markets are France, South America, and the United States. British manufacturers employ a special process by which the *crêpe* is waterproofed and does not lose its appearance when exposed to moisture. The trade declined considerably when mourning *crêpe* went out of fashion in this country, but, in France and other markets where it is still fashionable, the veil and important parts of dresses are of British manufacture.

A large quantity of *crêpe de Chine* is manufactured at Braintree, Norwich, and Yarmouth, but severe competition is now experienced from Japan.

(d) *Dress Silks.*—This is probably the weakest branch of the British silk industry, and it is the one in which foreign manufacturers practically hold the field. A small quantity of "net silk" dress goods are made in Macclesfield, in Lancashire, and in Yorkshire, and of mixed goods in the eastern counties. In Bradford and its neighbourhood, spun silk and mixed piece goods are made successfully. The great firm of Listers produces "pile" fabrics, which are known all over the world.

(e) *Lace, Net and Hosiery.*—These special articles are manufactured at Nottingham, Derby, Leicester, and in Devon and Somerset. The competition

met with is almost entirely from French millinery tulle. This industry is dealt with in the lace section of the report.

(f) *Narrow Goods, Braids, Ribbons, Hatbands.*—These are manufactured at Leek in Staffordshire, and to a less and decreasing extent at Coventry. Hat galloons are also made at Denton, furniture trimmings of the best quality in London, and the cheaper kinds at Leek, Macclesfield, Derby, and Coventry.

(g) *Furniture Silks and Specialities.*—Braintree is the chief centre for the manufacture of the richest brocades for court gowns, of figured velvets, and of other fine silk fabrics for decoration and upholstery. A considerable quantity of cheaper furnishing fabrics are manufactured at Bradford and Halifax mostly from spun silk mixed with cotton and wool.

(h) *Umbrella Silks.*—The finest umbrella silks are still made at Sudbury in Suffolk.

It will be seen that our manufacturers mainly devote themselves to turning out "specialities," in which they are able to hold their own against all their competitors abroad. The trade in the staple lines of plain and fancy dress goods is in the hands of four Continental countries—France, Italy, Germany and Switzerland—as well as Japan and China. Unlike the cotton industry, there is in the United Kingdom no large "plain" silk trade to permit of a very large outturn and corresponding enterprise on the part of manufacturers.

It is estimated that the wholesale value of silk goods annually consumed by this nation is £16,000,000, of which all but 20 per cent. is imported. The following table gives particulars about the imports in 1913:—

Country whence Imported.	Raw Silk.	Thrown Silk.	Spun Silk Yarn.	Silk manufactures and manufactures of Silk mixed with other materials if known as Silks.	Total.
European—	£	£	£	£	£
Allies	211,909	241,639	62,703	7,127,742	7,643,993
Enemies	26,901	207,286	19,411	2,515,701	2,769,299
Neutrals	—	15,827	114,633	3,266,570	3,397,030
Extra European—					
India	15,140	—	—	12,223	27,363
China	287,851	—	—	221,735	509,586
Japan	74,970	—	19,963	1,193,813	1,288,746
Other Countries	2,656	244	570	95,321	98,791
Total	619,427	464,996	217,280	14,433,105	*15,734,808

* Of this total nearly £2,000,000 was subsequently re-exported.

Japanese competition, as mentioned above, is regarded by our silk spinners as a very serious menace. The Committee was informed that the Japanese can sell the lower counts of spun silk yarns at less than the bare cost of production here. On labour cost alone the Japanese have an advantage of 1*s.* to 3*s.* per lb. Witnesses expressed the fear that unless an import duty is imposed on these yarns equivalent to the difference in the cost of labour, the British spinning industry will really be threatened. Imports consist of (1) high-grade plain and figured dress goods, ribbons and laces, and rich furniture silks, mainly coming from France; (2) plain and figured goods for men's and women's wear, such as taffetas, satins, coat-linings, tie silks, brocades, ribbons and trimmings of no particular merit, all heavily weighted in the dye and low in price, the chief sources of supply being Germany, Switzerland and Italy; (3) Eastern piece goods—Shantungs, Corahs, Pongees and Japanese Habutae.

The unsatisfactory position of the silk industry in this country is not due by any means to inferiority in quality. Actually, the productions of our mills are, on the whole, superior in design and colour to any foreign article—the French, of course, excepted. They also contain less adulteration and wear better. "The success of most foreign imports," says the Committee, "is due to their relatively low price. Germany, Switzerland and Italy have large silk industries, which are able to produce on a large scale. All of them 'dump' their surplus goods upon the free and open market of Great Britain." The general contention of witnesses was that the British industry cannot become a large one and manufacture on a large scale "unless it has some assistance from a tariff in its own market." From the replies to a *questionnaire* issued by the Silk Association, as well as from the oral evidence, it is clear, says the Committee, that the trade is almost unanimously in favour of the imposition of a tariff on imported piece and made-up goods as follows: Allies, 15 per cent. *ad valorem*; neutrals, 29 per cent. to 25 per cent. subject to reciprocal arrangements; undyed goods of Chinese and Japanese manufacture, 12 per cent. to 16 per cent. *ad valorem*; enemy countries, 40 per cent. With regard to thrown silk and spun silk yarns received from Allies, opinions are divided between free entry and a small duty.

Of our silk manufactures exported in 1913, valued at two millions sterling, 68 per cent. went to foreign countries. Our best pre-war

market for spun silk yarn was America—£227,000, out of £391,000. The value of all classes of our silk goods taken by the British possessions was £659,000, the figures being:—

Countries.	Spun Silk Yarn.	Broad Stuffs.	Lace.	Other Manufactures.	Total.
	Thousand £	Thousand £	Thousand £	Thousand £	Thousand £
Australia	17	65	1	77	160
New Zealand	—	6	—	20	26
Canada	17	121	3	74	215
South Africa	—	9	—	11	20
British India	14	62	—	18	94
Other	28	73	3	40	144
Total British Possessions	76	336	7	240	659

The Japanese have not only become keen competitors in our home market for two-fold weaving yarns, but have also captured a large portion of the trade which was formerly done by ourselves in India.

The finest silks are still woven in hand-looms, this being done generally by skilled workers in their own homes. On the other hand, there has been a great decline in this interesting domestic industry during the past two decades, so much so that at present the proportion of our hand-looms to power-looms is smaller than anywhere else in the world, excluding the United States. Lyons still possesses 15,000 hand-looms for brocades and delicate silk fabrics. Not one thousand are now used in this country.

Whatever may have been the case in the past, present-day silk manufacturers are well grounded in the technique of their craft. It is, we are told, a rare thing to find a working member of any firm who has not been through a course of practical instruction at Macclesfield, or Bradford, or Manchester. Some have been trained also at Lyons or Crefeld. Art and technical schools are established at the principal silk centres, but there is urgent need of an institution fully equipped with the more modern types of machinery, and in all respects equal to the best institutions of the kind on the Continent.

(To be continued.)

INDIAN INDUSTRIES COMMISSION.

The Indian Industries Commission have issued their report. According to a summary telegraphed from India, the administrative proposals include the creation of Imperial and Provincial Departments of Industries and of Imperial Industrial Service. The Imperial Department would be in charge of a member of the Viceregal Council, assisted by a Board of three members entitled the Indian Industries Board, and be responsible for the industrial policy of the Government and the inauguration and carrying out of a uniform programme of industrial development throughout the country. A large staff of officers would be employed, whose qualifications would primarily depend on a knowledge of mechanical engineering, and the formation of an Imperial Industrial Service is suggested.

Proposals are made for the better exploitation of the forests and fisheries. It is vital for the Government to ensure the establishment in India of those industries whose absence exposes us to grave danger in the event of war. The report advocates the introduction of modern methods of agriculture, and in particular of labour-saving machinery. The Commission recommends a special survey of the coal position in India. Attention should be directed to more economical methods of using wood fuel and new materials for industrial alcohol.

With regard to artisans, the Commission recommends universal primary education, and education of a technical kind is also required. For cottage industries the Commission proposes education in industrial schools, administered by headmasters with practical knowledge of the industries taught. In the case of organised industries mechanical engineering is taken as a typical instance, and the proposal includes the establishment of a system of organised apprenticeship for a period of four or five years. The Commission places better housing in the forefront of its recommendations to raise the standard of comfort of the Indian artisan. Special proposals are made for commercial and mining education, and the future establishment of two Imperial colleges is adumbrated, one for the highest grade of engineering and the other for metallurgy.

The Commission is disposed to favour the establishment of an industrial bank or banks, but considers that the appointment of an expert committee is necessary to deal with this subject, and asks the Government to take action at an early date. As an interim measure, a scheme is propounded for the provision of current finance to middle-class industrialists by which the banks would open cash credits in favour of applicants approved by the Department of Industries on the guarantee of Government.

The recurring cost of the proposals is estimated at eighty-six lakhs of rupees (£573,000), and they involve capital expenditure of 150 lakhs, mainly

on educational institutions, and a further capital outlay of sixty-six lakhs is anticipated for future developments. The Commission consider that this expenditure may be worked up to at the end of a period of seven years.

SIR GEORGE BIRDWOOD MEMORIAL.

The following appeal has been issued:—

Many friends of the late Sir George Birdwood have expressed a desire that his memory should be perpetuated in a tangible form.

It is felt that no more fitting memorial could be devised primarily than a "George Birdwood Lecture," to be delivered annually in connection with the Indian Section of the Royal Society of Arts, with which he was so closely associated for upwards of forty years, and in whose work he continued to take an active part almost to the very day of his death.

It is intended that the lecture shall be upon subjects relating to the art, literature, and social phenomena of India, the honorarium to consist of the Society's gold medal (with suitable inscription) or the equivalent in money, at the option of the lecturer.

The Council of the Royal Society of Arts cordially approve of the idea, and will be glad to administer the funds collected in accordance with the wishes of the donors.

Subscriptions may be paid to Mr. T. J. Bennett, C.I.E. (Honorary Treasurer), Royal Society of Arts, John Street, Adelphi, London, W.C. (2)

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TOBACCO IN HONDURAS.

An account is given in *Commerce Reports* (Washington) of Honduras tobacco, which has always enjoyed a pre-eminent position in the estimation of Central American tobacco smokers, so much so that native tobaccos of the neighbouring Republics are often put on the market under the name of "Tabaco de Honduras," in order to obtain higher prices. It is commercially known as "Copan tobacco," because the best quality and largest quantities are produced in the Department of Copan, which borders on both the Guatemalan and Salvadoran frontiers. It is also produced in commercial quantities in the Departments of Ocotepeque, Gracias, Santa Barbara, and El Paraiso, the capitals of the respective Departments being the marketing centres. The estimated average annual production of each district is as follows: Paraiso, 7,500 lb.; Santa Barbara 250,000 lb.; Gracias, 50,000 lb.; Ocotepeque, 410,000 lb.; and Copan, 1,000,000 lb.

Planting, Harvesting, and Curing.—Tobacco is planted during October—that is, from two to four weeks before the close of the rainy season—so that the young plants have sufficient time to take root before the long dry season sets in. The seeds are planted in nurseries during July, and the young sets transplanted about four months later. One pound of seed should produce approximately 20,000 plants, and growers place about 2,250 plants to the acre.

The leaves are ready for gathering between February and April, and the custom is to start harvesting as soon as the plant has fully developed. This is sometimes determined by the appearance of yellow tints in the leaves or when the leaves show signs of brittleness on being doubled or bent. The stock is cut whole a little above the roots, and the seed is obtained later from the suckers that sprout from the remaining lower part of the stem. The stocks are then hung out, head down, in the open air and exposed to the sun. If any are harvested in the rainy season (which is rare) they are dried in the shade. After being dried in the sun for fifteen or twenty days, the stocks are pressed for three days, and the leaves are then separated from the stems and sorted into three grades, according to size. They are then tied in bundles of 1 lb. each—the stems being utilised for fastening—and are alternately pressed and sunned until the veins are thoroughly dried. Owing to negligence and the varying judgments of different farmers, the resulting product is not always uniform, which sometimes results in obtaining lower prices. Dried leaves average from 9 to 20 inches in length, and a well-cultivated acre should yield from 400 to 650 lb.

Both strong, mild, dark, and light tobaccos are produced, these properties depending largely upon the nature of the soil and, to a somewhat lesser extent, upon the amount of rainfall and the time and method chosen for cutting and curing. If the plants are permitted to ripen thoroughly, the leaves will be rather dark in colour, whereas if cut earlier a lighter shade will be obtained. A poor, sandy soil is said to produce a mild tobacco, and a rich clay soil a somewhat stronger plant. In seasons of copious rainfall it is noticed that the leaves are invariably of a dark hue.

Cost of Production.—It costs from 8 to 12 cents United States currency to raise a pound of tobacco in Honduras, and the market price ranges from 15 to 25 cents, according to the class and quality It is supposed that most of the tobacco cultivated in Honduras was originally derived from Cuban seed, and the more progressive growers still continue to import Cuban, Jamaican, Porto Rican, and American seed. When ready for market Honduran tobacco closely resembles that grown in North Carolina and Virginia. It burns well and has a pleasant aroma, and connoisseurs state that its failure to achieve just recognition of its

worth is due solely to the primitive and unscientific methods employed in its harvesting and curing.

Methods of Packing—Export Trade in Tobacco.—Tobacco is packed for shipment in bales of 100 lb. each, which are well wrapped in several layers of banana leaves and tightly tied with strong banana fibre. Although apparently crude, this method of packing is considered the most practical, combining as it does the qualities of lightness and cheapness.

As the tobacco fields of Honduras are in closer proximity to the railroads and seaports of Salvador and Guatemala than to those of Honduras, nearly all the crop is strapped on the backs of native Indian runners or mules, and carried over the frontier trails to the neighbouring Republics. These caravans pass the border at remote hamlets, where no custom houses are established, so that statistics showing the volume of this trade are not available. However, it is well known that practically all of the high-grade cigars and cigarettes manufactured in Central America are either of pure Honduran tobacco or contain a large admixture of it. The amount and value of tobacco exports through the seaports of Honduras for the years 1915 and 1916 respectively were 56,800 lb., worth $6,810, and 89,025 lb., worth $19,610.

Honduras tobacco, after being manufactured into cigars and cigarettes in Guatemala and Salvador, is exported in considerable quantities to South America, particularly Peru, the Caribbean countries, and Europe. The volume of this business amounts to many thousands of dollars annually.

Efforts made to expand industry and markets.—Of recent years the Honduras Government has taken measures to foster the industry, and aside from maintaining several schools, where young natives are taught to cultivate and cure the crop scientifically, steps are being taken to improve the quality of the plants, and to find new outlets for the constantly increasing production. The Government recently sent several youths to the tobacco districts of Cuba, where they were able to study the up-to-date methods employed there in the various branches of the industry.

Tobacco is principally used in Central America for cigars and cigarettes; pipe-smoking and chewing have not been introduced among the natives, although nearly all of them, including women, smoke. Among the labouring classes the women of nearly every household prepare the cigars and cigarettes for the family needs. During the fiscal year 1914-15, $7,480 worth of cigarette paper was imported, the greater part of this supply coming from Spain and small shipments from the United States and Germany.

Up to the present no attempts have been made to manufacture high-grade cigars or cigarettes on a large scale, although, with an abundance of raw material and cheap labour, it would seem to warrant a careful investigation. Nearly every man and woman of the labouring class understands the rudiments of cigar-making, although none of them are particularly expert at it. However, they could soon be trained to turn out as good cigars as are manufactured in Cuba. An almost unlimited supply of this labour could be obtained at from 25 to 50 cents per day. Cigar factories in Guatemala utilise native labour, and their products (Honduras tobacco with Sumatra wrappers) are said to compare favourably with those of many factories in Cuba, Porto Rico, and the Philippines.

In addition to supplying the demand for good cigars in Honduras itself, a profitable market could be worked up among the other Central American Republics.

ENGINEERING NOTES.

The Cost of Railway Electrification.—Data now available covering the conversion from steam to electricity of several railway systems in the United States, show that the cost of conversion in the case of lines with a reasonable amount of traffic is amply justified from the financial standpoint. The Butte Anaconda and Pacific Railway, which was electrified in 1913 at an initial cost of £248,126, showed a total net saving per year over steam operation of £49,758, exceeding 20 per cent. upon the entire cost of the electrification. In addition to this definite money saving, the railway, according to the report, secured a greatly increased capacity and a much improved service, and these facts having been well acknowledged, the indications are that the Federal Government will take steps to conserve the existing supply of coal and fuel oil by assisting to finance such electrification as competent engineering authorities are able to show will make the greatest saving in fuel. In order to establish a definite ratio of comparisons between the efficiency of the steam locomotive and the electric system, data have been compiled showing that, as an average figure, 7 lb. of coal on the tender of a steam locomotive on the electric system is equivalent to a kilowatt-hour of electricity in the alternating current switch-board of the power-house. A kilowatt-hour of electrical energy can be produced in a modern plant with 2½ lb. of coal, the deduction therefore being that it requires 7 lb. of good coal in a locomotive fire-box to haul the same amount of net tonnage as could be dealt with by an electric locomotive burning 2½ lb. of coal in an up-to-date power-house. This information is taken from the *Railway Gazetté* of September 6th.

Steel Production of Manganese.—A leading article in the *Indian and Eastern Engineer* of July says that the production of a very considerable percentage of the world's output of steel is dependent on the supply of manganese ore, and as now the Russian supply is cut off, India is the largest producer. For the production, let us say, of 5,000,000 tons of steel requiring 17 lb. of 80 per cent. ferro-manganese per ton, at least 80,000 tons of the alloy would be required, necessitating the mining, transportation, and smelting of more than

200,000 tons of manganese ore. During the last peace years the world's output of manganese ore ranged from 2,000,000 to 2,250,000 tons, of which nearly one-half came from Russia. India, the second largest producer, had a production of 450,000 tons during 1915, and 645,000 tons during 1916; the next largest output is that of Brazil, which is less than one-third that of India. It follows that, however large the Indian output may be, there is a ready market for it, as all other countries do not in the aggregate produce one-third that of India. Russia exported large quantities of manganese ore to Great Britain—during the last peace year 241,800 tons — whilst the United States depended on Great Britain for supplies of ferro-manganese. Dwindling arrivals from this source have caused acute difficulties to American steel manufacturers. About 30,000 tons per month are required by them. No satisfactory substitute is known for ferro-manganese for the particular purpose for which it is used in steel-making, and in practice only an alloy with a high percentage of manganese is efficient.

The Reclamation of Scrap Iron.—The *Railway Gazette* of September 13th says that the iron and steel mills of the United States are greatly in need of scrap iron, the demand for this material far exceeding the supply. The railways have always been one of the largest sources of supply for scrap iron and steel, and the prices now being paid for such materials are sufficiently high to warrant special efforts in the collection of scrap. Apart from this consideration, it is felt that the railways should do their best to make up the deficiency for patriotic reasons. It has been calculated that if the whole of the iron and steel scrap in the country were marketed there would be no shortage of steel, but this can only be accomplished by very great effort. The railways can not only be of great help in collecting and marketing their own scrap, but they can do much by urging others with whom they come in contact to do the same, and by helping to promote and encourage "Sell Your Scrap" campaigns in the different communities which they serve.

New American Automatic Train-stop. — This device, invented by Mr. Schweyer, was exhibited in operation before a large company of railway officials and others on the Philadelphia and Reading Railway on Sunday, June 23rd. In this system an electric current (alternating) controlling air-brake valves on the locomotive is run through a choke coil, which is so fixed on the engine frame as to move in line with a "track armature" 30 in. long, fastened on the sleepers 13 in. outside the gauge line. The choke coil and the track armature are $2\frac{1}{4}$ in. apart, and there is nothing movable in either of them. On the passage of a train the armature weakens the current on the engine, and thus causes the setting of the brakes. A roadside battery, in connection with a short section of insulated track and an insulated truck of the locomotive, is arranged so as to neutralise this stop-operation, as may be desired, whenever the track ahead is clear. The tests were made under all three of the normal conditions—clear, caution and stop. The caution indication was arranged to reduce speed but not to stop the train, and the stop indication was arranged to apply the brakes in emergency. In the caution test, a service application of 15 lb. reduction was made, which resulted in a reduction of speed from approximately thirty-five miles an hour to about twenty miles an hour before the next ramp (track armature) was reached. This test was not considered satisfactory and it was repeated, with a service application of 25 lb. reduction. This application reduced the speed gradually from about thirty-five miles an hour until the train reached the next ramp, when it was brought to a stop in less than 100 ft. The test for a full stop was made at the entrance of the signal section, and there was no preliminary caution signal, with its ramp to give the customary reduction of speed. The speed over this ramp was approximately thirty-five miles an hour, and the train was brought to a stop in 700 ft. with the throttle open. After the regular tests were completed a number of runs were made to test the electro-magnetic fixture which is placed between the rails, and is designed for use on an electrified railway in place of the insulated track section. These tests, like the others, fully met expectations and requirements.

Electric Steel Production.—A recent development in the metallurgical industry which merits comment is the very great increase in the production of steel made by electric furnaces. According to Professor Carpenter, F.R.S., of the Imperial College of Science and Technology, previous to the war the output was so small that it did not figure in any returns of steel production. Nevertheless, in 1917 no less than 110,000 tons of electric steel were made, of which 90,000 tons were in the form of ingots and 20,000 tons in castings. At the present time upwards of fifty furnaces are at work in the various Sheffield works.

Aluminium and its Alloys.—Dr. Rosenhain, in an address on this subject at the British Science Exhibition, said that aluminium alloy was not a German monopoly. A Zeppelin framework had a tensile strength of 25 tons to the square inch, but this is not so good as the combination of lightness with high strength that could be produced in this country. Comparing steel having a tensile strength of 28 tons to the square inch, with pure aluminium of 7 tons strength to the square inch, he said that the length of a vertical bar of steel that could just carry its own weight would be 19,000 ft., and of aluminium 14,000 ft. But with alloy the length of the aluminium bar would be extended to 50,000 ft. In large structures like bridges the weight of the structure was so great that the weight of a train was almost negligible, but the point came where

the span could just carry itself; and, in comparison with steel, the light alloys of aluminium could increase the limiting span threefold. There was great expenditure of energy in starting and stopping electric trains, and if the heavy steel parts of locomotives could be replaced by light alloys there would be quicker starting and stopping, and an important saving.

OBITUARY.

Sir James William Restler, K.B.E., M.Inst. C.E., M.I.Mech.E.—Sir James Restler died suddenly at his residence in Queen's Gate on the 4th inst. Born in 1851 he was educated privately, and at King's College. In 1883 he was appointed Chief Engineer to the Southwark and Vauxhall Water Company, and on the acquisition of the Water Companies by the Metropolitan Water Board in 1904 he passed into the service of the Board. The works constructed under his supervision cost over £2,500,000, and included engines capable of raising 140,000,000 gallons of water per day, reservoirs to hold 1,800,000,000 gallons, very large filter-beds, five tunnels under the Thames, and a number of deep wells. He was consulting engineer to several private and local water enterprises, director of various companies, and chairman of the Metropolitan Munitions Committee. In recognition of his public services he was knighted last June.

He had been a member of the Royal Society of Arts since 1892.

GENERAL NOTES.

Enemy Aircraft Exhibition.—The exhibition of enemy aircraft at the Agricultural Hall, Islington, will be opened to the public on the 15th inst. Numerous types of machines will be on view, which will show not only their external features, but also their actual construction. Amongst other famous aircraft there will be on exhibition the Gotha, Friedrichshafen and A.E.G. bombing planes; the Halberstadt, L.V.G., D.F.W., Rumpler and Hannoveraner two-seater; the A.E.G. armoured trench fighter two-seater; and the Fokker, Pfalz and Albatross scouts. There will also be a complete array of engines and accessories, including wireless gear, machine-guns, bomb-sights, electrically-heated clothing, and innumerable aviation instruments.

British Industries Fair, 1919. — The 1919 British Industries Fair, organised by the Board of Trade, will be held, as last year, in the Pennington Street warehouse of the London Docks from February 24th to March 7th. In order that there may be no possible interference with the production of munitions, it will again be confined to the same trades as before, viz., glass and pottery; paper, printing and stationery; fancy goods; toys. The right to exhibit will be confined to British manufacturers.

Water-power in Tasmania.—The wonderful possibilities of Tasmania for the development of water-power are commented on in *Power*. The island possesses just in its centre, on a high elevation, a lake sufficiently large to provide its industries with all the electrical power that may be needed for some time to come. The basis of the whole system is the Great Lake. With a catchment area of 216 square miles, and a water area of 50 square miles, it forms an ideal foundation for a great hydro-electric enterprise. A dam that has been constructed on the southern outlet of the lake provides for an even depth of 11 feet above sill level, and experience has proved that this will be sufficient to guarantee a regular flow of water. Experiments made during the first year of operation have shown that during a year of normal rainfall a total of 70,000 horse-power can easily be obtained from the lake.

Anthrax.—In 1913 the Home Office appointed a Committee to inquire into the dangers from infection by anthrax in the manipulation of wool, goat hair, and camel hair. The Committee, of which Sir William Middlebrook, M.P., was chairman, presented their report—a very exhaustive one—on August 22nd last, and it has now been issued in the form of a Parliamentary Paper [Cd. 9171]. As an indication of the laborious character of the inquiry, it may be mentioned that the Committee met on 116 days, visited thirteen representative works, and examined forty-nine witnesses. The conclusion arrived at was that not only are the existing precautions inadequate, but that the danger is one which cannot be dealt with advantageously by regulations, and, given a satisfactory alternative, ought not to be dealt with in factories. Disinfection, the Committee consider, should be permitted only in central stations, preferably ports through which wool is exported to this country. For East Indian wool and goat hair they suggest Bombay and Karachi, for Persian wool Basra, and for Egyptian, Cairo. "The scheme of disinfection should be fitted into the existing trade organisations with as little disturbance as possible, and with sympathetic regard for existing institutions and customs." It is proposed that an organisation designated the "Disinfection Authority" should be constituted by Government and given the necessary powers to prevent the admission of dangerous materials into the country without disinfection. The scheme involves considerable expenditure. Having regard to the objects in view, the Committee recommend that the capital cost should be provided in the first instance by the British Government, the money to be repaid by means of a sinking fund, "provision for which should be made by a charge imposed on wool disinfected."

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FRIDAY, NOVEMBER 15, 1918.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

COUNCIL.

At a meeting of the Council held on Monday, the 11th inst., the following resolution was passed:—

"That this Council, happening to meet on November 11th, 1918, the day on which, at five o'clock in the morning, an armistice was signed between the Associated Powers and Germany, hereby places on record its deep gratitude to the Naval, Military, and Air Forces of the British Empire for the honourable and heroic part which they have played in bringing hostilities to this happy close."

ARRANGEMENTS FOR THE SESSION.

The Opening Meeting of the One Hundred and Sixty-Fifth Session will be held at 4.30 p.m. on Wednesday, November 20th, when an address will be delivered by ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council. The subject of the address will be "Science and the Future."

The following arrangements have been made for the meetings before Christmas:—

ORDINARY MEETINGS.

Wednesday afternoons, at 4.30 p.m.:—

NOVEMBER 27.—LORD D'ABERNON, G.C.M.G., Chairman, Central Control Board (Liquor Traffic), "Drink Control in Various Countries." SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., LL.D., F.R.C.P., F.R.S., Past President, Royal College of Physicians, will preside.

DECEMBER 4.—BENJAMIN SEEBOHM ROWNTREE, "Housing after the War." LORD HENRY CAVENDISH BENTINCK, M.P., will preside.

DECEMBER 11.—MAJOR-GEN. SIR FREDERICK SMITH, K.C.M.G., C.B., F.R.C.V.S., "The Work of the British Army Veterinary Corps at the Fronts." The DUKE OF PORTLAND, K.G., G.C.V.O., will preside. (The paper will be illustrated by the cinematograph.)

COLONIAL SECTION.

Thursday afternoon, at 4.30 p.m.:—

NOVEMBER 21.—SIR EVERARD IM THURN, K.C.M.G., C.B., LL.D., "The Present State of the Pacific Islands." SIR CHARLES LUCAS, K.C.B., K.C.M.G., will preside.

INDIAN SECTION.

Thursday afternoon, at 4.30 p.m.:—

NOVEMBER 28.—BHUPENDRANATH BASU, Member of the Council of India, "Some Aspects of Hindu Life." The Most Hon. the MARQUIS OF CREWE, K.G., will preside.

Papers to be read after Christmas:—

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S. (Subject to be announced later.)

SIR HERBERT JACKSON, K.B.E., F.R.S., F.I.C., F.C.S., "Trueman Wood" Lecture. (Subject to be announced later.)

FREDERICK WILLIAM KEEBLE, C.B.E., M.A., Sc.D., F.R.S. (Director of Horticulture, Food Production Department), "Food Production by Intensive Cultivation."

B. D. PORRITT, M.Sc., Chief Chemist, North British Rubber Company, "The Rubber Industry—Past and Present."

A. F. KENDRICK, Department of Textiles, Victoria and Albert Museum, "English Carpets."

H. KELWAY-BAMBER, M.V.O., "Railway Transport in the United Kingdom."

LIEUT.-COLONEL H. G. LYONS, D.Sc., F.R.S., "Meteorology during and after the War."

W. L. HICHENS (Messrs. Cammel Laird & Co.), "The Wage Problem in Industry."

SIR FRANCIS TAYLOR PIGGOTT, M.A., LL.M., "The Principles of Design in Japanese Art."

J. W. NORMAN WILLIAMS, "The Hawaiian Islands and their Industries."

J. J. CROWLEY, D.Sc., "The Use of Electricity in Agriculture in Germany."

Sir Frank Heath, K.C.B., Secretary, Department of Scientific and Industrial Research, "The Government and the Organisation of Scientific Research."

Walter Leonard Lorkin, A.M.I.E.E., "Electric Welding and its Applications."

Professor John Cunningham McLennan, Ph.D., F.R.S., "Water Powers and Scientific Development in Canada."

Sandford J. Kilby, "Indian Salt Manufacture."

H. Kelway-Bamber, M.V.O., "Coal and Mineral Traffic on the Indian Railways."

Professor H. E. Armstrong, LL.D., D.Sc., F.R.S., "Soil Exhaustion in India and its Influence on the Value of Crops."

Lord Montagu of Beaulieu, C.S.I., V.D. (Subject to be announced later.)

Further arrangements were announced last week.

EXAMINATIONS, 1918.

The diagram on page 795 shows the progress of the Society's examinations from the beginning of the present century. It will be seen from this that the number of candidates rose steadily from about 9,000 in 1900 to 29,000 in 1914. The effect of the war is very clearly shown in the sudden drop to 23,400 in 1915, and the still further fall to 19,300 in 1916. At this point the fall was arrested, and for a year the number remained almost stationary, the total in 1917 being 19,400. This is accounted for to a large extent by the fact that, although a great many who would otherwise have entered for the examinations had joined the Services, there was a great increase in the number of women candidates. This year the proportion of women is still higher, with the satisfactory result that the figures for 1918 show an increase of 3,400, as compared with those of last year. It may therefore be anticipated with considerable confidence that the examinations have already suffered the worst that the war could inflict on them. Next year, indeed, we may look for a further substantial rise. At the request of the War Office arrangements are being made for holding in February special examinations for troops on active service. Centres will probably be formed in France, Italy, Egypt, and at home. It is not yet possible to make any sort of estimate of the numbers likely to enter for these examinations; but, according to reports, a large number of the troops are availing themselves of the educational opportunities which the authorities of the Government are now providing for them.

As has been the case since 1914, the examinations this year were held at two periods, March and May–June. In March the number of candidates was 8,116, and in May–June 14,698. The numbers of papers worked were divided between the two examinations as follows:—

	March.	May.	Total.
Advanced Stage	563	2,447	3,010
Intermediate Stage	2,842	7,159	10,001
Elementary Stage	6,855	9,013	15,868
	10,260	18,619	28,879

The papers worked at the various Internment Camps abroad are included in the above table, but not in Table A on page 796.

In addition to the 22,814 examined in the written examinations, 256 candidates presented themselves for the *vivâ voce* examinations in Modern Languages. The total number of candidates examined in all subjects by the Royal Society of Arts in 1918 was, therefore, 23,070.

No changes of importance were made in the examinations programme this year. The subjects were: Arithmetic, English, Book-keeping, Shorthand, Précis-writing, Typewriting, Economic Geography, Economic History, Economic Theory, Commercial Law, Company Law, Accounting, Banking, Theory and Practice of Commerce, Commercial Correspondence and Business Knowledge, English for Foreigners, French, German, Italian, Spanish, Russian, Dutch, Rudiments of Music, and Harmony.

The total number of papers worked in Arithmetic was 2,743. The largest number of entries in this subject was in 1914, when the figure was 3,225. In 1915 this fell to 2,806, and in 1916 there was a further fall to 2,226. In 1917 there was a slight recovery to 2,349, and this has been continued in the present year by a rise to 2,743. Of these, 101 candidates entered for the Stage III. examination, of whom 4 obtained first-class certificates, 31 second-class certificates, and 66 failed. These results are exceedingly poor, and it is evident, as the examiner reported, that the great majority of the candidates did not possess the skill and knowledge necessary for this standard. The

results in the Stage II. examination were appreciably better, though the examiner has to complain of the lack of intelligence as well as of arithmetical knowledge in many candidates who misunderstood the meanings of the questions. The report on the work done at the Stage I. examination is very satisfactory.

There was a remarkable increase in the number of entries in English, the total 1,074 being considerably higher than in any previous year. Of these, 45 were in Stage III., 248 in Stage II., and 781 in Stage I. There seems to have been a general fall in the level of attainment in the Advanced Stage, though the work of the best candidates remains as good as ever.

The examination in English for Foreigners was instituted in 1916, on the suggestion of the Bradford educational authority that such an examination would be useful to a number of Belgian refugees in this country. In that year there were 547 entries. This figure dropped to 260 in 1916 and to 195 this year. The examination was, of course, only designed to meet a war-time need, and it is to be hoped that before the examinations are held again most of the refugees will have been repatriated.

Précis-writing no longer has the vogue that it once enjoyed. As a subject of examination it has been abandoned, to a very large extent, by the Civil Service Commissioners, who as a rule content themselves with setting a piece of narrative instead of a set of correspondence, with numerous letters to be indexed and docketed. This general tendency is reflected in the figures of the Society's examinations in this subject, which fell from 362 in 1911 to 74 in 1916. Last year, however, there was a slight rise to 85, and another to 95 in 1918.

The total number of entries in Commercial Correspondence and Business Knowledge was 2,430, showing a very considerable increase over last year's figure, 1,973. Unfortunately, with the increase of quantity there does not appear to be any corresponding improvement in quality. Of the 56 candidates who entered in Stage III. none obtained a first-class certificate, only 19 obtained second-class certificates, and 37 failed. In Stage II., again, of 420 candidates, only 9 obtained first-class certificates, 177 obtained second-class certificates, and 234 failed. The results are very unsatisfactory, and no doubt show, as the examiner suggests, that the instruction has proceeded on too narrow a basis.

The number of papers worked at the examinations in book-keeping was 8,023, of which 862 were in Stage III., 2,549 in Stage II., and 4,612 in Stage I. Book-keeping has always been the most popular subject of the examinations, the number of entries in 1914 being as high as 11,883. This dropped in 1916 to 6,687, but it now looks as if it were on the way to recover its pre-war dimensions. The examiner's report shows that this year the work on the whole is fair. He complains that many candidates were weak in dealing with income tax—which is, perhaps, more a matter for sympathy than surprise.

In Shorthand, which is, as usual, the second favourite subject, the figures for 1918 show a substantial increase over those for 1917 in each stage, the totals for the two years being 7,527 and 5,982 respectively. The examiner has gleaned his usual supply of quaint misrenderings, among which the most remarkable were "period of sinking" for "uprooted cinchona," "party government" for "uprooted coffee," "shop supplies" for "shipping space," "the least possible delay" for "the latest possible detail," and "for their manufacture" for "over from America." To the layman these blunders must seem simply fatuous and inexplicable; but anyone with a knowledge of shorthand outlines will see how they have arisen.

The number of entries in Typewriting, 2,589, shows an increase of 141 over the total of last year, and the results are very satisfactory. In Stage III., out of 117 candidates, 37 obtained first-class certificates, 62 obtained second-class certificates, and only 18 failed. In Stage II., out of 814 candidates, 179 obtained first-class certificates, 500 obtained second-class certificates, and 135 failed; while in Stage I. 1,256 passed out of 1,658. The examiner reports that the work on the whole was excellent, and decidedly in advance of the average of former years.

In Economic Geography there were 206 candidates in all, of whom 14 entered for the Stage III. examination, 51 for Stage II., and 141 for Stage I. It is satisfactory to note that the examiner reports "a very remarkable improvement" in the Stage III. and Stage II. papers. Although this total (206) is more than double that of last year (98), one would like to see a great increase in the numbers of entries, for there can be no doubt that in a community such as the British Empire, with its enormous geographical distribution and commercial interests, this subject is of vast importance, and ought to attract considerable numbers of serious

students. But doubtless in this, as in many other subjects, a great number of those who would normally have been candidates are engaged on active service.

In Economic History there were only 13 candidates for the Stage III. examination, and 16 for Stage II. The general level of the work seems to have been fairly satisfactory; but here, again, one would like to see a substantial increase in the number of entries.

It is somewhat remarkable that of the 59 candidates who entered for the examination in Economic Theory, 33 took the Stage III. examination, and 26 the Stage II. One hardly expects to find more entries for the Advanced than for the Intermediate Stage. The examiner's report on the Stage III. examination throws some light on this point: "too many [of the papers] were superficial and inaccurate, and the writers should not have attempted this stage of the examination."

The candidates in Commercial Law numbered 77, and those in Company Law were 54, as compared with the respective totals 65 and 41 in 1917. The examiner reports very favourably on the work done in both these subjects, and certainly the proportion of first classes is very large and that of failures very small.

There were 142 candidates in Accounting, as compared with 122 last year. The general average of merit appears to have been good. The examiner in Banking reports to the same effect on the work of his candidates, of whom there were 37, as compared with 29 in 1917.

The total number of candidates entering for Theory and Practice of Commerce was 210, of whom 55 took the Stage III. examination, and 155 Stage II. This examination was held for the first time in 1914, when there were 154 entries. Since then the figures have been 233 in 1915, 226 in 1916. and 180 in 1917. The examiner reports that numbers of the papers worked this year were very poor. The explanation is probably to be found in his surmise that many candidates take this subject at an age when they are quite unable to appreciate it properly.

The number of entries in French was 2,248, of which 507 were in Stage III., 832 in Stage II., and 909 in Stage III. The total entries in this subject during the last four years were: 2,954 in 1914, 2,784 in 1915, 2,285 in 1916, and 2,041 in 1917. In 1914 there were 793 entries in Stage III., so that the number for this year is still a good deal lower than the pre-war figure; but after all this is hardly matter for wonder, as so many of those who would have been advanced students are engaged on military or naval work. It is perhaps permissible to hope that after the war there will be a considerable increase of entries in the Advanced Stage, in view of the opportunities for studying French which have been afforded to large numbers of our soldiers. On the quality of the work done in Stages II. and III. the examiner presents a very favourable report.

One of the effects of the war is strikingly evident in the figures of the entries in German, the hatred of the enemy having evidently extended to his language. In 1914 the total in all stages was 826. In 1915 this fell to 462, in 1916 to 270, in 1917 to 215, and this year to 181. Of these, 35 entered in Stage III., 49 in Stage II., and 97 in Stage I. The work of the candidates appears to have been satisfactory, especially in the Advanced Stage.

The entries in Italian (80 in all stages) are satisfactory in so far as they exceed the pre-war figure of 76 for 1914; and there is a substantial rise as compared with the 53 entries of last year. Speaking generally, the work of the candidates appears to be fairly good.

In Spanish the entries were 289. The figure in 1914 was 355, but this had fallen in 1916 to 149. There seems to be considerable room for improvement in the work, especially in Stage III., where out of 42 candidates only 2 secured first-class certificates.

The figures in Russian are not uninteresting. Up to 1914, when there were 17 entries in all stages, the numbers were very small. In 1915 no examination in this subject was held. The events of that year, however, roused great interest in Russia, with the result that in 1916 there were 127 entries, which number increased to 266 the following year. It will probably be some time before we reach this figure again, for in 1918 the number had fallen to 157. This year's work in Stages II. and III. appears to show considerable improvement on that of preceding examinations.

Dutch has always attracted so few candidates that only on one or two occasions has it been found possible to hold an examination in this subject. This year only one candidate in this country presented himself. There were, however, a number of interned men in Holland who were anxious to be examined. As no fees are charged by the Society to prisoners of war and interned men it was at first doubtful if the examination could be held; but two donations of £20 each from the Directors of the Standard

Bank of South Africa and of the National Bank of South Africa removed the financial difficulty.

In Rudiments of Music there were 71 entries, as compared with 78 last year; and in Harmony 49, as compared with 50.

Oral examinations were held in French, German, Italian, Spanish, Russian, and English for Foreigners. The total number of candidates was 256 (as compared with 261 last year), of whom all (except 19 who were examined in Manchester) presented themselves at various centres in London. The numbers in the different languages were: French 176, German 17, Italian 16, Spanish 11, Russian 6, English for Foreigners 30. The details of the results of the oral examinations are given in Table B (page 797).

It is much to be regretted that the number of candidates entering for these oral examinations is so small. They have never been as large as they ought to be, in view of the importance of a colloquial knowledge of the subject in the case of a modern language. The highest number yet reached was 688 in 1913, since when the figures have steadily declined. It is, perhaps, permissible to hope that, now that so many possible candidates have had opportunities of studying foreign languages abroad, there may be an improvement in the numbers; and possibly, also, the newly instituted general certificate in modern language may induce a few candidates to enter.

The Court of the Clothworkers' Company have again renewed their grant of £40, to be expended in providing medals in all the subjects of examination where the work of candidates attains a sufficiently high standard. There is no doubt that these medals are highly valued by those who win them, and they have done much to maintain or raise the level of excellence in the papers worked. This year the Society has awarded 20 Silver Medals in the Advanced Stage, and 32 Bronze Medals in the Intermediate.

The arrangements made in 1916 and 1917 to enable prisoners of war and men interned abroad to enter for the Society's examinations were again repeated this year. The May examinations only were taken at Ruhleben, where 119 papers were worked by 58 candidates. Of these, 89 papers were in Stage III., of which 10 failed; 21 entered and passed in Stage II., while in Stage I. 9 papers were worked, of which 7 passed. The subjects taken up included Accounting, Book-keeping, French, German, Italian, Russian, and Spanish. The examiners in these languages report that the work of the candidates attained a high level of excellence. In German, *e.g.*, 26 candidates entered for the Stage III. examination, and of these 23 received first-class certificates, and the remaining 3 second-class certificates—a truly remarkable result.

Candidates from the British Naval Brigade interned at Groningen entered for both examinations. 91 papers in all were worked—22 for the Advanced Stage (12 passes and 10 failures), 43 for the Intermediate Stage (33 passes and 10 failures), and 26 for the Elementary (17 passes and 9 failures). The subjects were Arithmetic, Accounting, Book-keeping, French, German, Dutch, and Spanish.

At Chateau d'Oex 67 papers were worked in a variety of subjects at the two examinations. Of these 7 were in Stage III. (5 passes and 2 failures), 27 in Stage II. (24 passes and 3 failures), and 33 in Stage I. (26 passes and 7 failures).

At Mürren there were 16 candidates for the May examinations; 1 entered and passed in Stage III., 11 entered for Stage II. (of whom only one failed), and 4 took Stage I., none of whom passed.

The Examination Syllabus for 1919 has been issued. In it will be found the fullest possible information about the examinations, a syllabus of each stage of each subject, and a list of centres. The papers set in March and May, 1918,* have been reprinted in six pamphlets. Each pamphlet contains, in addition to the papers of each stage, the syllabuses of the subjects in the pamphlet and the examiners' reports on the papers worked in 1918. The attention of both teachers and students may be drawn once more not only to the syllabuses but also to the remarks of the various examiners on the results of last year. It will be found that these contain many valuable and helpful suggestions, and the work of the candidates year after year shows that far too little attention is paid to them. Teachers especially are earnestly recommended to study these reports, as they ought to be guided by them in the instruction they give to their pupils.

The regulations for the Examinations in the Theory of Music, and those for the Viva Voce Examinations in Modern Languages, are also given at full length in the syllabus.

* The price of the Syllabus for 1919 is 3*d*. post free. Copies can be obtained on application to the Examinations Officer, Royal Society of Arts, Adelphi, London, W.C. (2) The price of the pamphlets containing the 1918 papers is 3*d*. each, post free. Particulars of these may be obtained as above.

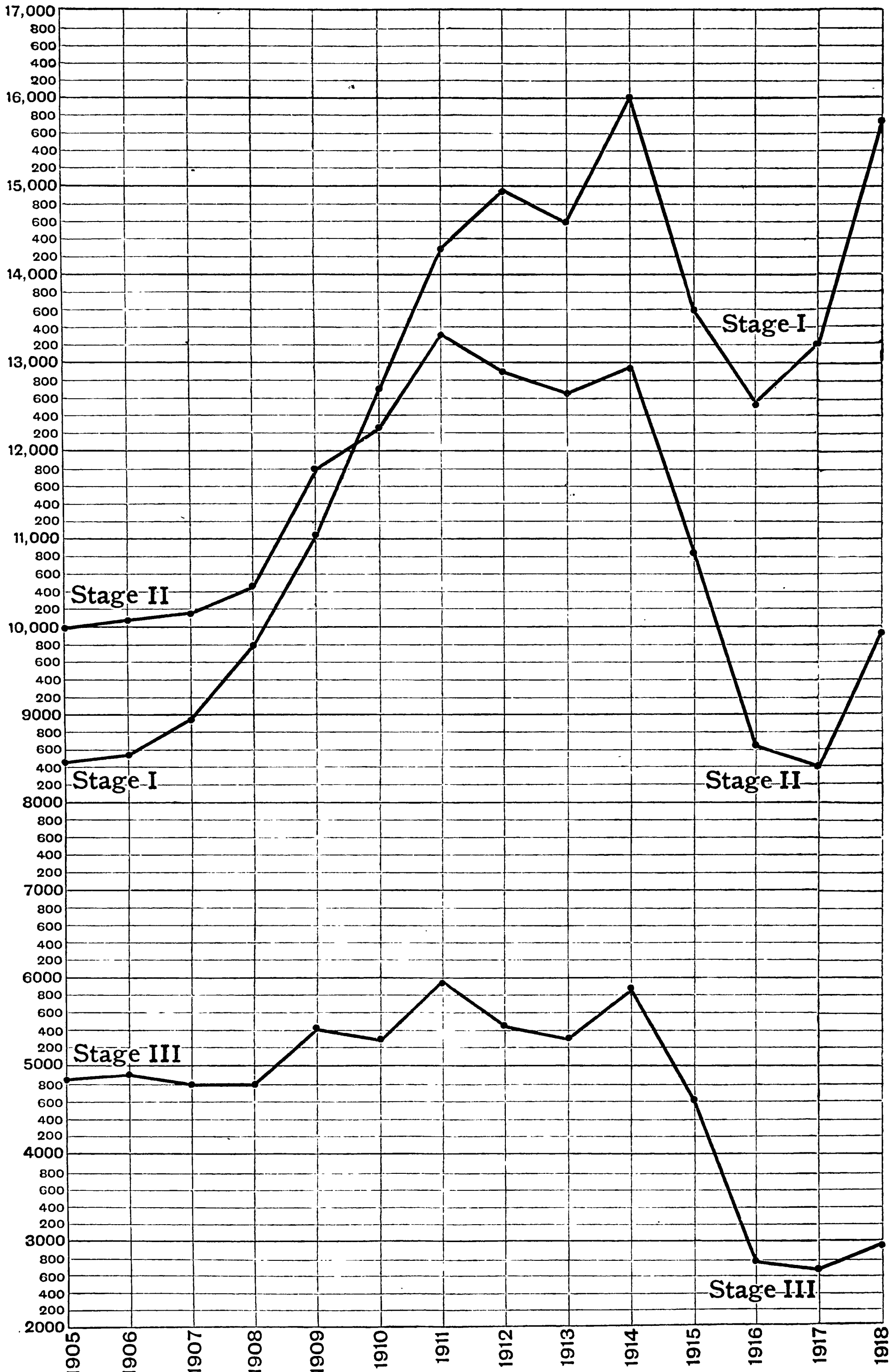

Diagram Showing the Numbers of Papers worked in the Three Stages, 1905-1918.—
I. Elementary; II. Intermediate; III. Advanced.

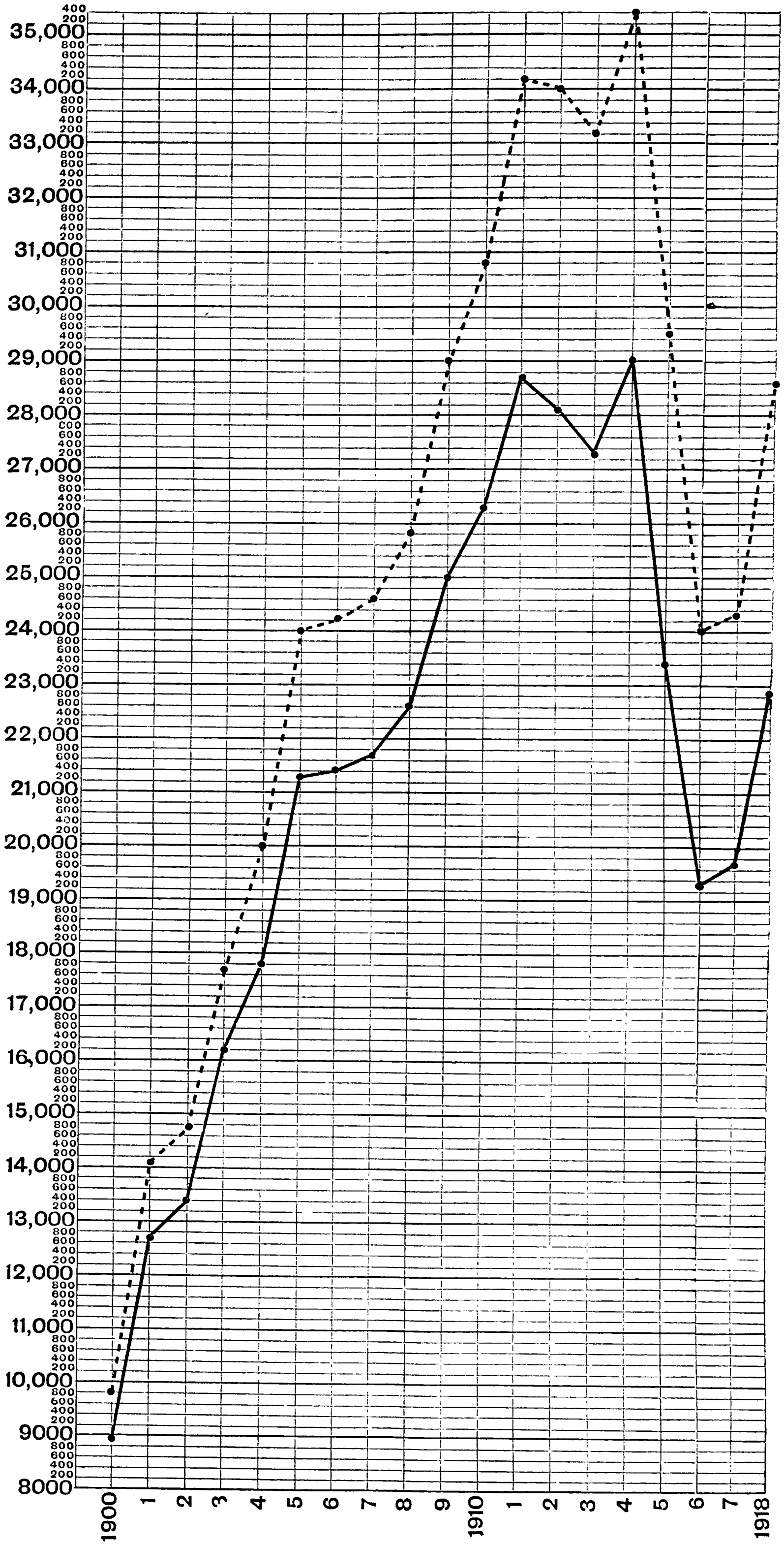

DIAGRAM SHOWING PROGRESS OF EXAMINATIONS, 1900-1918.

The continuous line shows the number of candidates, the dotted line the number of papers worked.

TABLE A.—DETAILS OF THE 1918 EXAMINATIONS.

SUBJECTS.	STAGE III.—ADVANCED.				STAGE II.—INTERMEDIATE AND MUSIC.							STAGE I.—ELEMENTARY.			Total number of papers worked in all stages.
								Music Certificates.							
	Papers worked.	1st-class certificates.	2nd-class certificates.	Not passed.	Papers worked.	1st-class certificates.	2nd-class certificates.	Higher.	Inter-mediate.	Elemen-tary.	Not passed.	Papers worked.	Passed.	Not passed.	
Arithmetic	101	4	31	66	520	36	229	..	..	..	255	2,122	1,371	751	2,743
English	45	7	17	21	248	40	140	..	..	..	68	781	481	300	1,074
Book-keeping	862	119	309	434	2,549	314	1,458	..	..	..	777	4,612	2,675	1,937	8,023
Economic Geography	14	3	8	3	51	1	28	..	..	..	22	141	83	58	206
Shorthand	539	63	266	210	3,778	529	1,351	..	..	..	1,898	3,210	2,110	1,100	7,527
Typewriting	117	37	62	18	814	179	500	..	..	..	135	1,658	1,256	402	2,589
English for Foreigners	62	2	24	36	71	2	46	..	..	..	23	62	36	26	195
Economic History	13	4	8	1	16	2	11	..	..	..	3	..	..	..	29
Economic Theory	33	5	19	9	26	5	14	..	..	..	7	..	..	..	59
Précis-writing	31	3	18	10	64	4	46	..	..	..	14	..	..	..	95
Commercial Correspondence and Business Knowledge	56	..	19	37	420	9	177	..	..	..	234	1,954	1,190	764	2,430
Commercial Law	77	27	37	13	..	..	..	..	..	..	..	..	..	..	77
Company Law	54	24	22	8	..	..	..	..	..	..	...	..	..	..	54
Accounting	142	27	65	50	.	..	..	..	..	..	..	..	..	..	142
Banking	37	5	17	15	..	..	..	..	..	..	..	..	..	..	37
Theory and Practice of Commerce	55	5	28	22	155	14	70	..	..	..	71	..	..	..	210
French	507	111	262	134	832	148	504	..	..	..	180	909	520	389	2,248
German	35	13	16	6	49	6	31	..	..	..	12	97	62	35	181
Italian	28	4	12	12	29	6	19	..	..	..	4	23	12	11	80
Spanish	42	2	27	13	76	7	59	..	..	..	10	171	130	41	289
Russian	21	6	11	4	80	18	49	..	..	..	13	56	34	22	157
Dutch	..	..	..	..	1	..	1	..	..	..	..	..	..	..	1
Rudiments of Music	..	..	..	..	71	..	..	23	..	33	15	..	..	..	71
Harmony	..	..	..	..	49	..	..	5	13	21	10	..	..	..	49
Totals	2,871	471	1,278	1,122	9,899	1,320	4,733	28	13	54	3,751	15,796	9,960	5,836	28,566

The above table does not include the papers worked at the various Camps for British Prisoners of War interned abroad.

TABLE B.

VIVA VOCE EXAMINATIONS HELD DURING 1918.

Centre of Examination.	Date.	Number of Candidates.	Passed with Distinction.	Passed.	Failed.
French :—	1918.				
Enfield Technical Institute	May 8	33	4	20	9
Kensington College	May 29	21	7	9	5
Manchester Education Committee	May 30	19	3	11	5
Pitman's School, London	June 4	18	9	7	2
,, ,, ,,	June 6	15	3	7	5
Regent Street Polytechnic (Candidates from London Institutions)	June 11	16	3	6	7
City of London College	June 12	18	1	9	8
,, ,, ,, (Candidates from London Institutions)	June 13	16	7	6	3
L.C.C. Education Offices (Candidates from L.C.C. Institutes)	June 18	20	8	10	2
German :—					
Regent Street Polytechnic (Candidates from London Institutions)	June 20	17	6	8	3
Italian :—					
Regent Street Polytechnic (Candidates from London Institutions)	June 28	16	6	7	3
Russian :—					
City of London College (Candidates from London Institutions)	June 19	6	1	4	1
Spanish :—					
City of London College	June 19	11	5	5	1
English for Foreigners :—					
L.C.C. Education Offices (Candidates from L.C.C. Institutes)	June 21	17	11	4	2
Regent Street Polytechnic (Candidates from London Institutions)	June 25	13	10	2	1
Totals		256	84	115	57

VEGETABLE WAX INDUSTRY OF JAPAN.

A Japanese industry which has made remarkable progress in recent years is that concerned with the extraction of vegetable wax, which is coming into greater demand on foreign markets. The output has been gradually increasing and now stands in the neighbourhood of 1,700,000 yen, or about £174,000 per annum. The work of extraction is being organised on a larger scale.

According to a report published by the United States Department of Commerce, the principal regions of production are in the island of Kiushiu, especially around the city of Fukuoka, which accounts for nearly half of the total output. The product is used abroad principally in the manufacture of polishes, pomade and soaps, and in dressing leather.

Most of this vegetable wax is derived from the fruit kernels of a tree peculiar to Japan, which begins to fruit at about fifteen years, and sometimes bears heavily when it is over a hundred years old. It reaches a height of 20 to 25 ft., and produces from 30 to 150 lb. of nuts annually. The best wax is made from nuts that have been kept over the winter, and, generally speaking, the quality of the product improves with the age of the nut. The wax is extracted by crushing and steaming the nuts, and then subjecting the mass to pressure. A second wax is secured by re-pressing. One workman can handle about 150 lb. of raw mass in a day, and this produces about 16 lb. of wax.

The crude wax, which solidifies at 50 degrees, is cast into round moulds of a little more than a pound each. It is next refined, the process used being a traditional one and peculiar to Japan. It is mixed with wood or charcoal, ash and water, thoroughly boiled, and dropped into cold water, so as to form what are called wax flowers. These are taken out and exposed to the sun for about twenty days, when the process of boiling, making the flowers, and sunning is repeated. The wax is then

boiled a third time, and the best quality taken off the top while it is in a molten condition. Recently improved methods have begun to come into use, and the crude wax is treated with an alkaline solution.

The most important foreign consumers of this product are the United States, Great Britain, France, and Hong-Kong, followed by various other countries of the Orient and Europe.

OBITUARY.

JOSEPH BLAMIRES.—Mr. Joseph Blamires died at Harrogate on November 5th, at the age of fifty-seven. He was head of the firm of Messrs. T. & H. Blamires, Ltd., woollen manufacturers, of Huddersfield.

In addition to his business activities, Mr. Blamires took a keen interest in municipal government, and was Mayor of Huddersfield for four years. He also worked to secure the extension of the Technical College, and was one of the principal workers in the movement that led to the establishment of British Dyes, Ltd. He was a director of the West Yorkshire Bank, and of the Huddersfield Building Society.

He was elected a Member of the Royal Society of Arts in 1910.

GEORGE CHELLEW.—Mr. George Chellew, who joined the Society in 1917, died on October 19th, at the age of twenty-five, from influenza and pneumonia. He was educated at King's College, London, and became a Science Master at a secondary school. He served in the Royal Fusiliers.

GENERAL NOTES.

THE "ENGLISHWOMAN" EXHIBITION.—The *Englishwoman* Exhibition of Arts and Handicrafts was opened at the Central Hall, Westminster, on the 13th inst., and will remain open until the 23rd. This is the eighth year that the exhibition has been held. The exhibits include weaving, pottery, toys, model buildings, etc. A special feature is the work of the wounded and permanently disabled soldiers and sailors who are trained at St. Dunstan's and Kitchener House.

SUBSIDIES.—Some months ago it was officially stated in the House of Commons that subsidies are granted to manufacturers of iron and steel to compensate for the increased cost of production. Replying to a question on the subject on November 7th, Mr. Kellaway (Ministry of Munitions) said that it would be impossible, within the limits of a Parliamentary answer, to give the scales of the subsidies, but it was estimated in July last that grants amounting to £17,000,000 had been approved. Recent increases had had to be given, owing to the further rise in the cost of coal and rates of wages. The Government is practically the only buyer, being the purchaser of 98 per cent. of the output. He added: "A Committee is now sitting with a view to seeing how soon the arrangement can come to an end in the event of the cessation of hostilities."

OIL FROM ALUM SCHIST.—A factory for extracting oil from alum schist has been started in Sweden. Large quantities of this schist, yielding benzine and crude oils, are found in the Lamma Nerika district. The crude oils, according to *Teknisk Ukeblad* of August 30th, can be used for oil-engines or converted into paraffin and lubricating oils. The factory is capable of treating 30,000 tons of schist per annum, giving 1,200 tons of oil. The supply of schist in Sweden is practically inexhaustible, and other factories will be erected shortly.

FISHERIES RECONSTRUCTION IN GERMANY.—A great deal is being done in Germany in connection with technical and scientific research in fisheries, and some account of it is given in the *Fish Trades Gazette* of October 26th. At Munich a great research institute has been founded for the study of the chemistry of food. It is intended to serve the interests of the whole Empire, and will be richly endowed. A sum of £150,000 to £200,000 has been set aside for building and equipment, and the annual revenue will be from £5,000 to £10,000. It is intended to make researches on the chemical composition and digestibility of all kinds of fish, fresh and preserved; on the effect of cold and other agents on its preservation and transport; on various methods of cooking fish; and on the so-called "fish-poison," or poisoning by bad fish.

SUGAR IN MAURITIUS.—This year's sugar crop in Mauritius promises to be one of the largest ever reaped. The Sugar Commission, however, has stated that it may not be possible to ship any considerable portion it to this country, and the Colonial Government will buy up the greater part of it. The Governor, in his address to the Council of Government last May, drew attention to the fact that no less than 43 per cent of the 1917 crop was produced by independent Indian farmers, a figure which, he observed, was the best reply to the arguments of those parties in India who are trying to prevent the emigration of Indian agriculturists to the colony.

Offer of a set of "Journals."—A set of unbound *Journals*, in good condition, extending from 1909 to 1918, has been placed at the disposal of the Secretary of the Royal Society of Arts for presentation to a public library or institution which will undertake to bind and preserve them. Applications should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. (2)

CONTRIBUTIONS TO THE READING-ROOM.

The Council have to acknowledge, with thanks to the Proprietors, the receipt of the following Transactions of Societies and other Periodicals.

TRANSACTIONS, ETC.

Aëronautical Society, Journal.
African Society, Journal.
American Academy of Arts and Sciences, Proceedings.
American Chemical Society, Journal.
American Institute of Architects, Journal.
American Institute of Electrical Engineers, Transactions.
American Institute of Mining Engineers, Transactions.
American Leather Chemists' Association, Journal.
American Philosophical Society, Proceedings and Transactions.
American Society of Civil Engineers, Transactions.
American Society of Mechanical Engineers Journal.
Amsterdam, Koloniaal Instituut, Bulletin.
Architectural Association, Journal.
Auctioneers' and Estate Agents' Institute, Record.
Australasian Association for the Advancement of Science, Report.
Australian Official Journal of Patents.
Bagnères-de-Bigorre, Société Ramond, Bulletin.
Barrow and District Association of Engineers, Transactions.
Bath and West of England Society, Journal.
Bombay, Royal Asiatic Society, Journal.
British Association for the Advancement of Science, Report.
British Dental Association, Journal.
British Fire Prevention Committee, Publications.
Canada, Royal Society, Proceedings and Transactions.
Canadian Society of Civil Engineers, Transactions.
Central Chamber of Agriculture, Journal.
Chartered Institute of Patent Agents, Transactions.
Chemical Society, Journal.
Chicago, Field Museum of Natural History, Publications.
———, Western Society of Engineers, Journal.
Cleveland Institution of Engineers, Proceedings.
Cold Storage and Ice Association, Proceedings.
Concrete Institute, Transactions.
East India Association, Journal.
Farmers' Club, Journal.
Franklin Institute, Journal.
Geneva, Société des Arts, La Revue Polytechnique.
Geological Society, Quarterly Journal.
Geologists' Association, Proceedings.
Glasgow, Royal Philosophical Society, Proceedings.
Imperial Arts League, Journal.
Imperial Department of Agriculture for the West Indies, Publications.
Imperial Institute, Bulletin.
India, Geological Survey, Memoirs and Palæontologia Indica.
Indian Meteorological Department, Monthly Weather Review.
Institute of Bankers, Journal.
Institute of Brewing, Journal.
Institute of British Carriage Manufacturers, Journal.
Institute of Chemistry, Proceedings.
Institute of Metals, Journal.
Institute of Sanitary Engineers, Journal.
Institution of Automobile Engineers, Proceedings.
Institution of Civil Engineers, Minutes of Proceedings.
Institution of Civil Engineers of Ireland, Transactions.
Institution of Electrical Engineers, Journal.

Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Gas Engineers, Transactions.
Institution of Mechanical Engineers, Journal and Proceedings.
Institution of Mining and Metallurgy, Transactions.
Institution of Municipal and County Engineers, Proceedings.
Institution of Naval Architects, Transactions.
Institution of Petroleum Technologists, Journal.
Iron and Steel Institute, Journal.
Japan Society, Transactions and Proceedings.
Johannesburg, Chemical, Metallurgical and Mining Society, Journal.
Junior Institution of Engineers, Record of Transactions.
Kew Gardens Bulletin.
Kyoto, Imperial University, Memoirs of the College of Science.
Lima, Ministerio de Fomento, Boletin.
Linnean Society, Journal.
Lisbon, Sociedade de Geographia, Boletim.
Liverpool, Engineering Society, Transactions.
———, Literary and Philosophical Society, Proceedings.
Lyons, Société d'Agriculture, Sciences et Industrie, Annales.
Manchester Literary and Philosophical Society, Memoirs and Proceedings.
———, Municipal School of Technology, Journal.
——— Steam Users' Association, Reports.
——— Textile Institute, Journal.
Michigan Academy of Science, Reports.
Milan, Associazione Elettrotecnica Italiana, Atti.
———, Collegio degli Ingegneri ed Architetti, Atti.
National Indian Association, "The Indian Magazine and Review."
National Physical Laboratory, Collected Researches.
New South Wales, Royal Society, Journal and Proceedings.
New York Academy of Sciences, Annals and Memoirs.
North-East Coast Institution of Engineers and Shipbuilders, Transactions.
Norwich, Operative Brewers' Guild, Journal.
Nova Scotian Institute of Science, Transactions.
Paris, Comité International des Poids et Mesures, Procès Verbaux.
——, Conservatoire National des Arts et Métiers, Annales.
——, Société d'Encouragement pour l'Industrie Nationale, Bulletin.
——, Société de Géographie Commerciale, Bulletin.
——, Société des Ingénieurs Civils, Mémoires.
——, Société Internationale des Electriciens, Bulletin.
——, Société Nationale d'Acclimatation de France, Bulletin.
Patent Office, Illustrated Official Journal.
Pennsylvania (Western), Engineers' Society of, Proceedings.
Philadelphia, Academy of Natural Sciences, Proceedings.
Philadelphia, Engineers' Club, Journal.
Physical Society, Proceedings.
Quekett Microscopical Club, Journal.
Royal Agricultural Society, Journal.
Royal Asiatic Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Canadian Institute, Transactions.
Royal Cornwall Polytechnic Society, Annual Report.
Royal Dublin Society, Proceedings and Transactions.
Royal Horticultural Society, Journal.
Royal Institute of British Architects, Journal.
Royal Institution of Great Britain, Proceedings.
Royal Irish Academy, Transactions and Proceedings.
Royal Meteorological Society, Quarterly Journal and Record.
Royal National Life Boat Institution, "The Life-Boat" and Annual Report.
Royal Sanitary Institute, Journal.
Royal Scottish Society of Arts, Transactions.
Royal Society, Philosophical Transactions and Proceedings.
Royal Society of Edinburgh, Transactions and Proceedings.
Royal Statistical Society, Journal.
Royal United Service Institution, Journal.
St. Louis Engineers' Club, Journal.
Smithsonian Institution, Report and Publications.
Society of Antiquaries, Archæologia and Proceedings.
Society of Architects, Journal.
Society of Biblical Archæology, Proceedings.
Society of Chemical Industry, Journal.
Society of Dyers and Colourists, Journal.
Society of Engineers, Transactions.
South African Association for the Advancement of Science, Report.
South Wales Institute of Engineers, Proceedings.
Tokyo, Imperial University, Journal of the College of Science.
Tramways and Light Railways Association, Journal.
Victoria Institute, Journal of the Transactions.
Washington, National Academy of Sciences, Proceedings.
Wisconsin Academy of Sciences, Transactions.

JOURNALS.

Weekly.

Aeronautics.
Amateur Photographer.
American Gas Light Journal.
American Machinist.
Architect.

Auto-Motor Journal.
Board of Trade Journal.
Bradstreet's.
British Journal of Photography.
Builder.
Building News.
Cabinet Maker.
Chemical News.
Chemist and Druggist.
Colliery Guardian.
Contractors' Record.
Economist.
Electrical Review.
Electrician.
Electricity.
Engineer.
Engineering.
English Mechanic.
Flying.
Gardeners' Chronicle.
Greater New York.
Grocer.
Indian Engineering.
Industrial Australian and Mining Standard.
Iron and Coal Trades Review.
Journal of Agricultural Research (Washington).
Journal of Gas Lighting.
Lancet.
Leather.
London County Council Gazette.
London Teacher.
Machinery.
Machinery Market.
Mechanical World.
Medical Press and Circular.
Model Engineer and Electrician.
Motor Traction.
Musical Standard.
Nature.
Near East.
Page's Weekly.
Pharmaceutical Journal.
Pitman's Journal.
Pottery, Glass and Brass Salesman.
Practical Engineer.
Produce Markets' Review.
Public Opinion.
Pulp and Paper Magazine of Canada.
Railway News.
Sanitary Record.
Saturday Review.
Science.
Scientific American.
Shipping World.
Spectator.
Textile Mercury.
Work.

Fortnightly.

Agricultural News (Barbados).
Dyer and Calico Printer.
Finance Chronicle.
Jeweller and Metalworker.
Junior Mechanics and Electricity.
Madrid Cientifico.
Perak Government Gazette.
Revue Générale des Sciences.
West India Committee Circular.

Monthly.

Acetylene Lighting and Welding Journal.
American Photography.
Analyst.
Arms and Explosives.
Automobile Engineer.
Board of Agriculture Journal.
Bookseller.
Brewers' Journal.
British Esperantist.
British Trade Journal.
Cassier's Engineering Monthly.
Chamber of Commerce Journal.
Chimie & Industrie.
Cold Storage and Ice Trades Review.
Co-partnership.
Cotton (Atlanta).
Decorator.
Engineering Review.
Gas and Oil Power.
Geographical Journal.
Geographical Review (New York).
Giornale del Genio Civile (Rome).
Horological Journal.
Ice and Cold Storage.
Illuminating Engineer.
Imperial Colonist.
Industrial Management (New York).
International Sugar Journal.
Investor's Monthly Manual.
Leather Trades' Review.
Master Builder.
Miller.
Mining Magazine.
Moniteur Scientifique.
Musical Times.
Mysore Economic Journal.
Notes and Queries.
Paper Maker.
Paper Makers' Monthly Journal.
Philosophical Magazine.
Photographic Journal.
Popular Science Monthly (New York).
Pottery Gazette.
Power User.
Propriété Industrielle (Berne).
Science Abstracts.
Scottish Geographical Magazine.
Secretary.
Steamship.
Studio.
Symons's Meteorological Magazine.
Textile Manufacturer.
Textile Recorder.
United Empire.
Watchmaker, Jeweller, and Silversmith.
Water and Water Engineering.
Wireless World.

Quarterly.

Agricultural Journal of India.
Botanical Journal.
Colonial Journal.
Edinburgh Review.
Educational Times.
Quarterly Review.
West Indian Bulletin.

NEWSPAPERS.

Canadian Gazette.
Ceylon Observer (Overland Edition).
Englishman (Calcutta).
Home and Colonial Mail.
London and China Telegraph.
London Commercial Record.
Madras Weekly Mail.
Newcastle Weekly Chronicle.
Pioneer Mail (Allahabad).
South Africa.
Times of Ceylon (Weekly Summary).
Times of India (Overland Weekly Edition).

The issue of many of the Publications formerly received by the Society has been interrupted by the War, and their names have been temporarily removed from this list.

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EDUCATIONAL SUPPLEMENT.

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